Route to:

Return to:

INSTITUTE OF GAS TECHNOLOGY

THE GAS INDUSTRY'S OWN EDUCATIONAL AND RESEARCH FACILITY

CHICAGO 16, ILLINOIS

GAS ABSTRACTS

MAY, 1959

VOLUME 15 NUMBER 5

AFFILIATED WITH

ILLINOIS INSTITUTE OF TECHNOLOGY

CONTENTS

1. **Management**—Gas industry progress, business problems, statistics, government regulation, safety, personnel, education.....137

2. **Energy Supply and Economics**—Resources, reserves, and competitive applications of the fossil fuels and other sources of energy, including nuclear and solar energy.....142

3. **Natural Gas and Petroleum Production**—Geology, exploration, drilling, well management, reservoir engineering.....144

4. **Gas Conditioning and LPG Recovery**—Condensate, dust, CO_2 and sulfur removal, dehydration, odorization, oil fogging, humidification; LPG recovery and refining.....149

5. **Natural Gas Transmission**—Pipelines, compressors, dispatching, flow regulation, communications, maintenance.....151

6. **Gas and LPG Storage**—Holders, pressure tanks, underground storage; liquefaction, refrigerated storage.....154

7. **Manufactured Gas and Chemical Processing**—Gasification of coal, oil; reformed gas; chemical treatment; byproducts; synthesis gas production and conversion; petrochemicals; catalysts, catalyst development.....155

8. **Gas Distribution**—City utility systems: design, operation, maintenance; weather influence on peak loads and supply; LPG-air mixtures.....159

9. **Gas Fuel Utilization and Appliances**—Domestic, commercial, industrial; burners; combustion research; air pollution.....161

10. **Equipment and Instrumentation**—Production and handling equipment, and maintenance; computers; controls; measurement.....165

11. **Materials of Construction, and Corrosion**—Metals, refractories, plastics; corrosion measurement, prevention.....168

12. **Analytical Methods and Tests**—Standard and research techniques for gas-making materials, products, processes; instrumental analysis.....170

13. **Basic Science**—Chemistry, physics and basic engineering related to gas technology; physical properties of gases: phase equilibria, thermodynamics, reaction kinetics, heat and mass transfer, fluid flow.....173

Services Available to Readers—Photocopies, microfilm, Russian translations, bibliographies and literature searches, *Gas Abstracts on Cards*, back numbers of *Gas Abstracts*.....**Inside Back Cover**

Publications Abstracted for Gas Abstracts.....**Back Cover**

O. P. BRYSCH, Editor — P. J. CHATTA, Assistant Editor

GAS ABSTRACTS is published and distributed monthly by the Institute of Gas Technology, Chicago 16, Illinois. The contents of selected papers and patents are reviewed impartially by the editorial staff and material of potential interest to the Gas Industry is presented. Subscription rates to non-members of the Institute: $18.00 per year to U.S. addresses; $22.00 foreign—Printed in the U.S.A.

Copyright 1959 by the Institute of Gas Technology.

A microfilm edition of Gas Abstracts can be supplied by University Microfilms, 313 N. First St., Ann Arbor, Michigan.

1. MANAGEMENT

Methane Liquefaction

Role of Regulation in Developing Use and Transportation of Liquefied Methane. W. R. Connole. *Gas Age 123,* 32 (1959) Apr. 2 (4 pp.); **Liquefied Methane Gas. A Serious Competitor to Pipe Line Gas?** *Pipe Line News 31,* 35 (1959) Apr. (4 pp.)

Successful transportation of liquefied methane could change world pattern of energy use . . . cost estimates indicate that natural gas from abroad can compete with pipeline gas in coastal U.S. . . . need for a national policy with respect to import is indicated. With the price of wellhead and costs of transportation increasing, Eastern seaboard distributing companies are losing or soon will lose many of the markets into which valley sales used to be made. Until such time as gas-fired air conditioning or some other off-peak use is found, the high cost of incremental additions to the load curve of the average distributing company actually threatens the rate of growth of the gas industry. Here is where liquefied methane holds the greatest promise.

Gas Industry Expansion

Gas Industry Heats 19 Million Homes: Gain of 6 Percent Made in Past Year. (New York: A.G.A. Release No. 22-N9.) 1959 (May 6.)

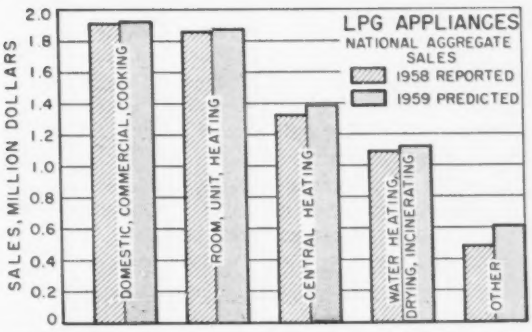
Nation's gas utility companies added 1,079,000 new residential heating customers during 1958 and increased the number of gas-heated homes by 6% to establish a record total of 19,003,000, A.G.A. reports. Nearly 65% of all residential gas customers now heat their homes with gas, a gain of 2.3% from 62.6% a year ago.

The Pipeline to Sunshine. J. F. Ebdon. *Gas 35,* 53 (1959) May (8 pp.)

Background of the development of Houston Corporation's pipeline system from Texas to Florida probes into the situation beginning in the early 1950's. Problems, prospects and outlook at that time are exposed. Article touches on the men whose vision will culminate in the opening of the system this June. Distribution properties acquired by Houston Corporation are listed. Market in terms of industrial growth potential is discussed. Estimated number of customers during first three years of operation is tabulated.

A Look at Distribution Company Gas Purchasing Problems . . . from Slide-Rule to Crystal Ball. C. H. Frazier. *Gas Age 123,* 23 (1959) Apr. 2 (3 pp.)

Problems arise from the nature of the increase in gas demand, the physical complexities of bringing gas 2000 miles to market, and regulations. Answers at the moment at least appear to lie in unusual prudence, foresight and, unfortunately, an abundant use of the "crystal ball."



(Data from *This Is Your Industry.* See abstract, p. 138.)

The Case for ACTION and Gas Utility Support Thereof. E. H. Eacker. *Gas Age 123,* 36 (1959) Apr. 2 (3 pp.)

Author has served on board of ACTION (American Council to Improve Our Neighborhoods) since its inception. He believes that unless this country begins now to increase building and to rehabilitate older homes and apartment houses, at least 30 million Americans will be living in sub-standard housing 15-20 years from now. It's a problem where good sense now can bring a sound return in dollars for the local utility as well as good living for its customers.

Gas Industry Management

A New Approach to Natural Gas Producer Regulation. R. L. Conkling. *Public Util. Fortnightly 63,* 593 (1959) Apr. 23 (14 pp.)

Because of the dual nature of the gas industry, cost-of-production and cost-of-service methods of establishing a rate of return for natural gas producers do not prove satisfactory. Author suggests that the competitive nature of the industry be used as a real foundation for natural gas field price regulation. He believes competitive bidding by individual producers would set standards for new prices as well as guideposts against which existing contracts could be gauged for reasonableness.

Unaccounted-For Gas

Factors Affecting Unaccounted-for Gas. J. H. Glamser, J. S. Janssen and L. C. Rohret. *Gas Age 123,* 25 (1959) Apr. 16 (5 pp.)

Unaccounted-for gas may be troublesome and costly. Much of it does not appear as unaccounted-for gas as reported by conventional methods. Recogni-

tion of these hidden losses and their magnitude and cost will supply operating men and management with additional information on which to base their judgment in channeling and planning their efforts to reduce unaccounted-for gas. Report is summation of studies made during past several years. Techniques and methods proposed and employed are not perfect, but they do give reasonable results which may be improved upon and refined as additional experience is gained. Only the major items are included; remaining items are relatively small for most companies.

Federal Power Commission

A New Blow to Gas Producers. *Petrol. Week 8,* 9 (1959) Apr. 10 (2 pp.); **Phillips Ruling Not Policy . . . Yet.** *Oil Gas J. 57,* 66 (1959) May 4.

Federal Power Commissioner examiner recommended a utility-type cost-of-service method to determine natural gas rates for Phillips Petroleum Co. — a method which may become a precedent for federal regulation of most independent producer gas prices. Highlights of new ruling: Rate bases would be determined by actual costs, rather than by the fair field price method producers had sought. Major limitations would be applied to what may be included in costs. (This may substantially reduce many rate bases.) A rate return of 9.25% would be established. Allocation of joint oil and gas exploration costs would be based on the relative values of oil and gas reserves added by successful exploration — and not on a Btu content of production.

LPG

This Is Your Industry. (First Annual Survey of the LPG Industry.) *Butane-Propane News 21,* 33 (1959) May (16 pp.)

Survey starts with composite dealer, who has 1383 customers the largest segment of which is domestic. Average dealer has 800 customers. Grand total of customers represented by survey is 675,081, which represents about 7-8% of the industry's estimated total of about 9 million. Total gallonage sold by surveyed dealers in 1958 was 496,331,816, or about 11.4% of all gallonage sold through the industry excluding non-retail uses such as gas manufacture, industrial and chemical manufacture. Survey also showed that in diversification, the smallest companies are undisputably ahead of the bigger ones. In househeating, which is a good measure of market penetration, they also lead. Differences between the various segments of the industry become much more apparent when dealers are classified geographically. Dealers also are optimistic about 1959. In one category alone, ranges, dealers estimate a 23% increase in sales.

Foreign Activities

Without Iraq, Arabs Talk Softly on Oil. *Business Week 1548,* 24 (1959) May 2; **Arabs Leave No Doubt They Want a Bigger Share of the Profits.** *Oil Gas J. 57,* 78 (1959) May 4 (2 pp.); **Nasser Speaks Up on Oil for the First Time.** *Petrol. Week 8,* 18 (1959) May 1 (2 pp.)

Delegates from Saudi Arabia, other Mideast oil produring countries and Venezuela met in Cairo to lay down the law to the big oil companies. At the completion, the Arabs had temporarily failed in their bid to form a united front for negotiating better deals with the oil companies. Only two practical results emerged: 1) Lebanon's proposal for a joint government-company development fund for such transit countries as Syria and Jordan; 2) Saudi Arabia's proposal for a new pipeline similar to Aramco's Tapline but controlled by Arab governments.

Natural Gas in Venezuela. C. P. de la Cova. *Gas Age 123,* 26 (1959) Apr. 2 (3 pp.)

With liquefaction opening world markets to Venezuela natural gas, that country is planning a large-scale development of its resources, particularly for export. Present resources permit export of 500 million CF in liquid form. Current proposals call for purchases at $.07-$.10/MCF. Problem of gas waste is urgent, however. Comparison of the production and utilization of gas in Venezuela and in the U.S. (average 1955 for U.S. and average 1956 for Venezuela) indicates: 1) Proportionally, the amount of gas reinjected at Venezuela (18%) is larger than in the U.S. (13%); 2) industrial utilization in the U.S. is 65% against 4% in Venezuela. Only way to solve gas waste problem in Venezuela is to plan a large-scale program for industrial development, particularly in the export field.

Walsall. New Plant Multiplies Gasworks Capacity. C. J. P. de Winton. *Gas J. 298,* 169 (1959) Apr. 22 (7 pp.); **Pleck Works Walsall.** *Gas World 149,* 770 (1959) Apr. 25 (8 pp.)

Commissioning of new plant at the Pleck works at Walsall in Staffordshire has increased its potential gasmaking capacity from 4.75 MMCF/d to a total of 18 MMCF/d. New gasmaking plant—comprising four benches of 24 Woodall-Duckham lambent-heated continuous vertical retorts, and two Humphreys & Glasgow carburetted water gas plants—replaces a carbonizing plant of 30 W-D continuous vertical retorts with a capacity of 4 MMCF/d and a small Humphreys & Glasgow plant of .75 MMCF/d. Plans for expansions were drawn up in 1950 when the West Midlands Gas Board, after reviewing the future demands for gas in Walsall and surrounding

districts, decided that the Pleck site should be developed to its maximum capacity. New plans were prepared. Scheme was difficult to carry out because, in the early stages controls on building and scarcity of materials were serious problems. Sloping site also was an awkward one for a works of such size. In addition, it was necessary to maintain uninterrupted production of gas throughout the entire work of reconstruction.

Walsall: Commissioning Procedure at the New Works. G. W. Harvey. *Gas J. 298*, 177 (1959) Apr. 22 (3 pp.)

Plans for expansion of the Pleck works at Walsall in Staffordshire included: 1) Installation of a new steam driven exhauster of 6 MMCF/d capacity; 2) Installation of another second-hand Livesey washer; 3) Splitting of the stream on the outlet of the electrostatic detarrer into three separate streams and 4) combining the three streams at the outlet of the purifiers before passing through the benzole washer which was to be converted to a zinc acetate washer.

Switzerland: Its Prospects. Molasse Basin is the Key Area. A. A. Heim. *World Oil 148*, 209 (1959) Apr. (4 pp.)

Oil and gas possibilities of Switzerland, particularly in the Molasse Basin, continue to appear quite favorable. Nation has not been adequately prospected, however, due to the lack of laws to allow, much less encourage, exploratory drilling. There has been little popular support toward encouraging such exploration though legislation. However, some Swiss cantons are modifying their laws to legalize drilling and production.

Central Gas Plant of Grand-Quevilly. P. Verret. *J. Ind. du Gaz 83*, 107 (1959) Mar. (12 pp. French text.)

Main production center at Rouen and the lower Seine basin gas pipeline network of 280 km are described in considerable detail. This area, which includes Paris, LeHavre, Rouen, is linked to the eastern and northern pipelines.

Exploration

Can We Keep Exploration Alive? M. W. Haas. *Petrol. Eng. 31*, B-58 (1959) Apr. (3 pp.)

Oil always has been hard to find — today it's just more expensive. Unless costs are cut, cheaper produced crudes or some other form of energy will supplant domestic crude. Aggressive action is needed to tell others — business, civic, educational and governmental leaders — about industry's problems, because these groups also are affected.

Wildcat Risks Cut Back Exploration. B. W. Blanpied. *Drilling 20*, 59 (1959) Apr. (3 pp.)

Taking all new field wildcats into consideration, there has been almost a constant success-to-failure ratio. Average for 15 years has been 11.15%, with a range from a low of 9.97% to a high of 12.22%. Even more significant than these figures has been the study of total ultimate reserves of oil discovered by these new field wildcats. Study, based on fields having a minimum of six years' development history, shows that on an average only one new field wildcat out of every 43 drilled discovers a field with as much as one million barrels of estimated ultimate reserves; that is, an average of 38 dry holes are drilled for every profitable field discovered by new field wildcat wells.

Ethylene

Survey of Ethylene Chemicals' Upcoming Five Years of Plenty. *Chem. Week 84*, 36 (1959) Apr. 25 (18 pp.)

Within the next five or six years, the petrochemical industry will be turning out $11-12 billion worth of product. By 1965, petrochemicals will account for about 33% of an anticipated 260 billion lb of industrial chemical production, and 65-70% of the estimated value ($16.7 billion) of industrial chemicals produced in the U.S. Towering over the other major petrochemical segments is the ethylene industry which today contributes nearly $2 billion worth of product to the economy. Report defines outlook for ethylene oxide and derivatives (ethylene glycol, ethanolamines, non-ionic surfactants, acrylonitrile, etc.); polyethylenes; ethanol; halogenated ethylenes (ethyl chloride, ethylene dichloride, ethylene dibromide); strene and related products. Ethylene itself will be appraised in a separate, future report. All forecasts assume there will be no marked change or international political climate, that there will be a continuance of a reasonably high level of prosperity, with no serious economic depression or major war.

Ethylene Chemicals Outlook: Surge to '65. Ethylene. *Chem. Week 84*, 79 (1959) May 9 (14 pp.)

In the two decades beginning in 1945, ethylene output in the U.S. will have multiplied eightfold, reaching a figure of 6.5 billion lb/yr. As a measure of comparison, production of butylenes, propylene and acetylene will climb, respectively, to 3.6 billion lb., 2.7 million lb. and 900 million lb. by 1965. During 1959, ethylene consumption may exceed 4.5 billion lb., nearly 50% greater than chemical use in 1955. Acetylene, however, has moved forcefully into ethylene markets. Well over half the vinyl capacity in the U.S. uses acetylene-hydrogen chloride, whereas a few years ago, ethylene (via ethylene dichloride) was the preferred raw material. Acry-

lonitrile is another once-important ethylene outlet now almost lost to acetylene. While competition between ethylene, propylene and butylene is not direct, derivatives of these do compete in many cases; i.e., ethylene oxide and glycol vs propylene oxide and glycol; ethanol (ethylene), isopropanol (propylene), butanol (butylene). Also significant is the increasing rivalry likely among polypropylene, polyethylene and polystyrene.

Helium

Helium and Argon: Rare Gases Due for Big New Boosts. *Chem. Week 84,* 86 (1959) Apr. 25 (2 pp.)

U.S. consumption of argon and helium will be accelerated in the next two or three years. Evidence to support this statement is that current acute helium shortage is being alleviated by construction of two new producing facilities and special fabricating techniques used in manufacture of supersonic aircraft soon will boost argon demand. One of the new helium facilities is privately owned; the other is another government helium extraction plant, the U.S.'s fifth, being constructed near Boise City, Okla., at the Keyes natural gas field. It is a $12-million installation that will be able to produce some 200-290 MMCF of helium annually from a throughput of 70 MMCF/d of a natural gas that contains 2% helium. Completion date: mid-1959.

Research

Picking Europe's Research Brains. *Business Week 1547,* 78 (1959) Apr. 25 (6 pp.)

U.S. demand for research work has overloaded available facilities so badly that farming out the work abroad looks like the only answer for many companies. Contract research—thinking, calculating and doing laboratory work for other people at a fee—is itself a relatively new idea for Europe. It is only since 1947 that Europeans generally have been convinced of the value of farmed-out research—both as clients and contractors. Difficulty is that the few research organizations that do this work are overloaded, and scientific skill shortage keeps them from expanding. Countries that do offer facilities include Norway, Sweden, Denmark, England, Holland, France, Switzerland and Italy. Also available are a few U.S.-owned research institutes operating in Europe.

The Work of the British Coke Research Association. G. W. Lee. *J. Inst. Fuel 32,* 154 (1959) Apr. (16 pp.)

Review of some of the many aspects of work performed by the B.C.R.A. during the past 14 years. During this time, the Association has expanded in a relatively normal way as indicated by the fact that its income has increased from £17,000 in 1944 to a revenue of about £140,000 for 1959. In manpower, the increase has been to a work force of 101. History of Association's establishment, its policies and fields of research are described.

API Names Battelle to Seek Better Oilheating, New Uses. *Fueloil & Oil Heat 18,* 50 (1959) Apr. (2 pp.)

Planning of a research program for the improvement of existing oil burner equipment and development of new uses for fueloil will be undertaken by Battelle Memorial Institute, Columbus, Ohio, under the sponsorship of the API. Work on the project has been initiated and it is expected to continue for a 12-month period. It will be supervised by the Fuel Oil Committee of the Division of Marketing.

Fuel Oils

How Are Fueloil Men Doing in the Battle to Prevent Failures of Customers' Tanks? *Fueloil and Oil Heat 18,* 14 (1959) Apr. (2 pp.)

During 1958, the fueloil and oil heating companies had 9.4 tank failures/thousand in use. They replaced with new tanks 5.5/thousand and repaired 3.9 tanks/thousand. This shows considerable deterioration from three years ago when the total tank failures were running 7.7/thousand and of those 5.7 were being replaced and 2.0 were repaired.

Petrochemicals

New Petrochemical Intermediates . . . for Detergents. G. E. Hinds. *Oil Gas J. 57,* 96 (1959) Apr. 13 (2 pp.)

New method has been developed for the manufacture of higher-molecular-weight straight-chain alcohols. This process has been licensed to Continental Oil Co. under the Ziegler patents. Principal attractive features of the Alfol development will be to the detergent industry as a new source of raw materials. Pilot development is close to completion and present plans call for a commercial plant to be in operation by 1961.

Cost Accounting

Cost-imating for Gas Distribution Construction. J. H. Anderson. *Am. Gas J. 186,* 30 (1959) May (4 pp.); *Gas Age 121,* 33 (1959) Apr. 30 (4 pp.)

Article is concerned with problems in distribution construction estimating as experienced at the Minneapolis Gas Company and tells how the company solved them. At the end of 1958 construction season, rapidly expanding company comprised some 2000 miles of mains, 184,000 services and 214,000 meters. Company has been growing at the rate of about 90 miles of main and 6000 services annually.

During 1959 it expects to install an additional 120 miles of new main and connect 10,000 new customers to its system. A 10% error in projection of costs would throw budgeted allocations off by nearly a million dollars. With experience as key factors, cost-imating was envisioned as three-legged table: 1) Properly supervised construction force that is able to accurately indicate charges according to established internal accounts; 2) Property evaluation department that can filter, separate and compile these charges, and 3) engineering brain-trust to organize these cost figures into a usable form peculiar to future needs.

Fight on Utility Accounting. *Business Week 1548,* 25 (1959) May 2.

Three major operating subsidiaries of American Electric Power Co. are asking the federal district court in New York to make permanent a temporary injunction against the American Institute of Certified Public Accountants. Injunction forbids institute to send out a letter clarifying its stand on the treatment of tax reserves from accelerated depreciation until the letter has been submitted to the Institute's regular procedures. Behind dispute is fact that AICPA policies, though not legally binding, are generally treated as a definition of acceptable accounting procedures by accountants, the courts, and such regulatory agencies as the Securities & Exchange Commission. In the present case, acceptance of the institute's policy would mean that the American Electric Power group would have to transfer more than $66-million from equity accounts to "deferred liabilities." Other utilities—including Pacific Gas & Electric, Consolidated Edison and Cleveland Electric Illuminating Co.—would have to make similar transfers.

Public Relations

When the Allegheny 'Dropped Its Ice' . . . M. M. Thrash. *Gas Age 123,* 36 (1959) Apr. 16 (2 pp.)

Last January, flood emergency plagued the town of Kittanning, Pa. Peoples Natural Gas Co. offices there won praise for its handling of the situation in which 1) gas lines had to be shut down to keep water out; 2) emergency supplies had to be delivered to a local hospital and 3) post-flood checking of service lines had to be performed before gas could again be used for mid-winter heating. Crew performed these tasks in three days.

Air Pollution

Air Pollution Abatement . . . A Management Problem. L. B. Hitchcock. *Chem. Eng. Progress 55,* 49 (1959) Apr. (5 pp.)

Under today's prevailing conditions, prudent management will prepare its own statement of company policy on air pollution abatement, and promulgate this statement in terse, lucid form throughout the organization. This should be done even where no air pollution problem is known to exist at present. Problems can develop rapidly today in unexpected quarters. Notwithstanding the absence of a recognized problem at the moment, policy should require that the potentials for a problem should be carefully evaluated by a team within the company's own organization.

Safety

Fire Research Pays Process Dividends. *Chem. Eng. 66,* 84 (1959) Apr. 20 (2 pp.)

Union Carbide Chemicals Co.'s fire research men conducted work on 1) fire safety characteristics, 2) explosibility and stability studies and 3) special problems related to fire protection engineering. This shows that fire protection, formerly a defensive function, now is contributing basic improvements to process and equipment design as well as to operating procedures.

The Hazards of Natural Gas Pipe Lines. A. J. Johnson. *Coal-Heat 75,* 16 (1959) Apr. (3 pp.)

Author utilizes assumptions and those statistics which disfavor natural gas pipeline systems, primarily from the standpoint of safety, to strengthen the case for coal.

Safe Handling of "Reactive" Chemicals. A. B. Steele and J. J. Duggan. *Chem. Eng. 66,* 157 (1959) Apr. 20 (12 pp.)

Article reviews Union Carbide Chemicals Co.'s experiences in handling of reactive chemicals. "Reactive" chemical is defined as a material which will vigorously polymerize, decompose, condense or otherwise react with itself in the pure state—or in the presence of a catalytic amount of some other material—or which will react violently with water.

Maintenance

Preventive Maintenance Gets Full Usable Life from Your Equipment. R. H. Illingworth. *Oil Gas J. 57,* 112 (1959) Apr. 27 (4 pp.)

Three types of maintenance are in common usage: breakdown repair; periodic maintenance and preventive maintenance. Latter is type of maintenance that prevents major breakdown and emergency repair and gets the full usable life from the component parts of equipment. To develop a maintenance program that is truly preventive means using various indicators of wear and establishing limits of wear and component life.

2. ENERGY SUPPLY AND ECONOMICS

Gas Reserves

Gas Industry Increases Underground Storage Capacity to 2.7 Trillion Cubic Feet in 1958. (New York: A.G.A. Release No. 26-N9.) 1959 (May 14.)

Gas utility and pipeline industry, which has invested an estimated $650 million in natural gas storage facilities to meet peak demands of its 32 million customers, has boosted its underground reservoir capacity to 2.7 trillion CF, according to an A.G.A. release. At the end of 1958, the industry had nearly 1.8 trillion CF of gas in storage. A.G.A.'s eighth annual underground storage report shows that four states — Pennsylvania, Ohio, Michigan and West Virginia — account for more than two-thirds of the total gas in storage reservoirs at year-end. A total of 205 storage pools and 8237 active wells are operating in 19 states, an increase from 199 pools and 7969 wells a year ago. Two states have shown exceptional growth in storage: Iowa more than doubled its capacity, climbing from 13 to 31 billion CF, while Texas increased from 26 to 38 billion CF. Compressor stations required for underground storage operations also have expanded. The 130 compressor stations in 1957, with 411,000 total horsepower, have increased to 136 stations with 438,000 horsepower.

Nuclear Energy

The Role of Nuclear Power in the Next Decade. P. J. Searby and J. G. Smith. *J. Inst. Fuel 32,* 172 (1959) Apr. (2 pp.)

Authors outline the development of the United Kingdom's nuclear power program for the construction of 5000-6000 MW of nuclear generating capacity by the end of 1966, and discuss possible future developments in British reactor design and the use of nuclear energy. Authors point out that nuclear energy, as an alternative to other forms of fuel, can be used for purposes other than electricity generation. Its use is being studied for propulsion, for direct heating, for chemical processing and for other tasks. Contribution of nuclear energy in these fields is unlikely to form a significant proportion of total fuel consumption in the next 10-15 years. It would be unwise, authors believe, to hazard a guess as to the possibilities in these fields in the more distant future.

Energy Sources

Resources, Population Growth, and Level of Living. V. E. McKelvey. *Sci. 129,* 875 (1959) Apr. 3 (7 pp.)

Brief analysis of relations of population growth and level of living to natural and human resources yields several relatively simple but important principles. Means for a man's subsistence increase with increasing constructive consumption of raw materials and energy and, especially, constructive use of ingenuity. Resources of usable raw materials and energy may be increased to an unpredictable extent by the development and application of ingenuity. Most fundamental stimulus to ingenuity is a basic ideology that challenges, encourages and rewards individual initiative, freedom of thought, desire for economic gain and thirst for knowledge. Attainment of a high standard of living requires that the ratio of consumption to consumers be high. Such a ratio can be maintained most easily if the population is sufficiently educated to understand the benefits and the means of family limitation and to extend its control over its physical and human environments by peaceful means.

Future Energy Sources for Pennsylvania. J. J. Schanz, Jr., R. K. Amole, D. G. Frendzel, J. N. Hoffman and W. B. Jaworek. (University Park, Pa.: Mineral Industries Experiment Station Circ. No. 53.) June (1958).

Objective of research was to determine energy sources available to the state of Pennsylvania and to evaluate those energy sources not currently employed but which may offer promise for the future. It is expected that the future energy requirements of the State will be extremely large, but the energy sources within the State and available to it from without will be more than adequate for at least 50 years with only a gradual increase in their cost. Fossil fuels offer the most promise for the lowest cost energy in the State for the remainder of this century. Pennsylvania is an important producer of fossil fuels. State will benefit from the experience gained by the utilities as well as from the development of economic atomic power. By 1985, or at least 2000, a gradual shift toward economic atomic power plants of the latest design will be desirable in Pennsylvania. By this time, oil and gas will no longer be available to the State in large quantities.

Petroleum Reserves

New Charts . . . Speed Oil Property Present Worth Calculations. L. F. Ivanhoe. *World Oil 148,* 174 (1959) Apr. (3 pp.)

Recently developed graphs facilitate calculation of the present worth of oil properties and are especially useful for rapid qualitative evaluations. Graphs were designed for use with a universal chart to obtain appropriate discount factors which permit rapid comparisons between the potential values of a well at different decline rates. Such charts should be used with proper recognition of their limitations, and

should never be considered substitutes for detailed evaluations by competent engineers. Two factors always are included in any estimate of the present worth of oil reserves or future production: 1) Estimated rate of decline of the oil wells and 2) interest discount factor for the future income.

How to Appraise Wildcat Prospects. G. C. Hardin, Jr. Part 1. *World Oil 148,* 119 (1959) Mar. (2 pp.); Part 2. *Ibid.,* 139 (1959) Apr. (4 pp.)

Within a period of two years, Michel T. Halbouty Oil and Gas Interest compiled the following record using method described to determine economic factors in the geological appraisal of wildcat prospects: 1) Two unprofitable fields were found out of six discoveries by new field wildcats; 2) two unprofitable fields were found out of four discoveries by new pool wildcats, and 3) the ratio of profitable fields to total fields discovered was approximately 1 to 1.7. Part 1 discusses profit-to-risk ratios and success-to-failure ratios, plus geological criteria to be considered in making evaluations. In Part 2, ways to estimate possible profit and permissible tolerances are presented, plus some excellent examples of prospect evaluation.

Petroleum Production

Productive Capacity Gain to be Small. *Petrol. Week 8,* 12 (1959) May 8.

Rise in domestic productive capacity of all liquid hydrocarbons in the U.S. this year will be the smallest in years, with an increase of only 187,000 bbl/d now anticipated. Gain expected for 1959 compares with increases of 213,000 bbl/d in 1958, 273,000 in 1957, 346,000 in 1956, 534,000 in 1955 and 550,000 in 1954. Gain in crude productive capacity in 1959 will amount to 157,000 bbl/d to a total of 9,813,000 bbl/d. Gas liquids productive capacity is expected to increase by 30,000 bbl/d to 960,000 bbl/d. Based on the anticipated production of all petroleum liquids in early 1960, the "spare" productive capacity as of the first of next year will amount to about 2.2-million bbl/d or about 20% of total capacity.

China's Growing Oil Industry. R. Westgate. *Petrol. 22,* 127 (1959) Apr. (5 pp.)

China's crude oil output last year reached about 2.2 million tons, compared with 1.4 million tons in 1957. In the past few years, the country's output has been increasing at an annual rate of 20-27%. Last year's boost of something over 50% is in line with Chinese industry's current "leap forward" as part of a mammoth campaign to overtake Britain in output of major industrial items in the shortest possible time. Special article outlines China's ambitious plans to make herself a major oil producing country.

Petroleum

United States Intensifies Quest for Foreign Oil; Russia Expands in World Markets During 1958. H. W. McCobb. *J. Petrol. Tech. 11,* 14 (1959) Feb. (5 pp.)

For foreign oil operations the year 1958 was one of adjustment and change rather than a year of crisis or sensational discovery. It marked the establishment of trends that are likely to be of great significance in the years to come: 1) Entry of more and more U.S. oil firms into foreign operations; 2) penetration of the Free World oil markets by Russia, and 3) a trend toward more government participation in oil ventures. The year 1958 also was a year of industry-wide overcapacity. These trends are discussed briefly, including some of the more significant developments in selected countries.

Origin and Migration of Oil. E. G. Baker. *Sci. 129,* 871 (1959) Apr. 3 (4 pp.)

Relationship exists between the composition of crude oil and the solubility of the component hydrocarbons in dilute colloidal electrolyte solutions, suggesting that crude oil consists of hydrocarbons that were once solubilized in formation waters. It is not solubility in ordinary water or solubility in complete soap solution that correlates with the composition of oil but, rather, solubility in soap micelles. Because it implies a possible unloading mechanism, this concept is attractive, for it follows that when a soap solution is diluted with water, the soap micelles disperse and the hydrocarbons solubilized therein appear as discrete, filterable oil droplets. In addition to the implications regarding the composition of crude oil that are inherent in the hypothesis that crude oil collects from aqueous colloidal electrolyte solutions, there are several interesting implications from the geological viewpoint. To mention one, such a mechanism would lend credence to the suggestion that the source beds of petroleum are not necessarily unique accumulations of hydrocarbons in a limited area but, rather, may generally be coincident with the area from which water is expressed into the porous strata that eventually form the reservoirs.

Foreign Activities

New Canadian Gas Field Develops Fast. *Petrol. Week 8,* 23 (1959) May 8.

Proved reserves from four gas wells in Alberta's year-old Carstairs field has spurred the building of a 33-mile pipeline and a multi-million dollar processing plant. Field as it now stands is being consolidated into a 12-section unit with reserves estimated at 550-billion CF of gas. Gas is contracted to

Trans Canada Pipe Lines, Ltd., at $13.25/MCF. Gas will be fed into Trans Canada's 2290-mile line from Alberta to Montreal. Morever, Carstairs wells are each capable of producing several hundred bbl/d of condensate.

Drilling

Drilling for Oil in 1975. R. O. Childers. *Petrol. Eng. 31,* B-19 (1959) Apr. (6 pp.)

During the next 15 years, the depth of U.S. oil wells will double . . . but the problems associated with drilling these wells will be multiplied many times. Author doubts assumption that drilling designs in 1975 will approximate those of today for economic reasons alone. Finished machine steel used in oil machinery delivers at the rough estimate of $.70/lb. Converting these figures to dollars, the cost before considering risk and operation totals $5,185,000. Recalling the share of the 1975 energy market predicted for oil and gas, this does not look very logical. Hence, the challenge: Can industry meet competition for the energy market of 1975? Author discusses future energy market, mechanical developments, logging at 50,000 ft, inadequacy of present techniques, high cost of inspection, miracle muds, production stimulation and the rig of 1975.

Electricity

Peoples Gas Studies Cost Data: Gas vs. Electric Househeating. *Gas Heat and Comfort Cooling 10,* 82 (1959) Apr.

Peoples Gas Light and Coke Co. has added electricity to a summary of comparative fuel costs for residential space heating it has been preparing and distributing since 1947. According to the study, seasonal cost of heating a larger centrally heated dwelling in Chicago with gas is $167. Same house costs $669 to heat with electric resistance, and $334 to heat with an electric heat pump. Gas heating costs for the smaller centrally heated dwelling representative of homes now being built would be $137. For the same house, electric resistance costs $551 and an electric heat pump $275. Table of comparative costs is given.

Solar Energy

Solar Energy. Economics and Engineering Research at the University of Wisconsin. J. A. Duffie and G.O.G. Löf. *Can. J. Chem. Eng. 37,* 77 (1959) Apr. (8 pp.)

Use of solar energy, in most applications, is dependent primarily on economic considerations; solar energy can become an important energy source when the costs of its use become competitive with the costs of energy from other sources. Basic and usually most costly item of equipment for solar energy utilization is the collector, or solar heat exchanger, and the amortization of the first cost of this and associated equipment is the major cost of solar energy. The probable economic feasibility of several solar applications is assessed by using the costs of energy from present sources as a basis for estimating upper limits on the first cost of solar heat exchangers and their association equipment. For example, for space heating in temperate climates, heat exchanger costs would have to be in the range of $1-6 for solar heating to be competitive; this appears to be within an attainable range. Economic considerations have helped shape the development of the Wisconsin solar energy program, and studies of solar heat exchangers and their application to heating, cooling and power generation are briefly reviewed.

Thermoelectricity

Thermoelectric Devices: Tomorrow's Competition? D. Hale. *Am. Gas J. 186,* 25 (1959) Apr. (3 pp.)

It must be realized that use of electrical power will continue to grow at an even faster pace than other forms of energy. As fossil fuel reserves in this country decline in coming years, new ways of supplying energy must be discovered. Today, most electric power is supplied through indirect energy conversion —by using fossil fuels (gas, oil, coal) to provide heat energy, which is converted to mechanical energy in a turbine. This energy is then converted from mechanical energy to electrical energy by using generators. Indirect conversion, theoretically, is not an efficient method of producing power—today's modern steam-electric generator plants operate at efficiencies of 30-40%—yet, it remains the only practical method for large-scale power generation.

3. NATURAL GAS AND PETROLEUM PRODUCTION

Air Drilling

New Tools, Methods Speed Spread of Air/Gas Drilling. *Drilling 20,* 72 (1959) Apr. (3 pp.)

Although water encroachment problem apparently is near solution, air/gas drilling proponents face a still substantial—but shrinking—list of obstacles. Wild holes, resulting from faster penetration and fewer trips to change bits, are being attacked through further study of drill string assemblies and attempts to design a suitable continuous deviation logging device. Undergage hole problem, a production of long

bit runs, is under study and the sloughing hole problem still lacks a solution. But air/gas drilling, with its demonstrated advantages and its recognized risks, has won the recognition of suppliers, contractors and operators as a hole-making process with a future that will greatly overshadow its past.

What the Past Year Taught Us about Air Drilling. F. W. Smith. *Oil Gas J. 57,* 169 (1959) Apr. 27 (3 pp.); **New Techniques Are Opening Up New Areas to Air and Gas Drilling.** F. W. Smith. *World Oil 148,* 188 (1959) May (3 pp.)

Past year was one of great advancements in air and gas drilling. Of primary importance was the development of methods and materials to combat formation water that enters the hole while drilling. These developments were in three categories: 1) In "weeping zones," dry chemical powders added to the air stream waterproof the cuttings and prevent balling. 2) In intermediate flows, "mist drilling" with foaming agents keep formation water moving out of the hole. 3) When flow is heavy, silicon tetrafluoride gas promises to be a cheap, fast way to shut off flow entirely.

Core Testing

The Alteration of Rock Properties by Percussion Sidewall Coring. G. M. Webster and G. E. Dawsongrove. T.N. 2031. *J. Petrol. Tech. 11,* 59 (1959) Apr. (4 pp.)

It has been recognized for some time that certain discrepancies exist between core analysis data obtained from percussion cores and data obtained from other types of core samples. Article presents existing field and laboratory data that were available to the authors. Several examples of comparative core analysis data obtained from various fields are presented along with photomicrographs of thin sections of conventional and percussion cores. Results of investigation are presented to aid in clarifying the possible disturbed condition of percussion sidewall cores.

Laboratory Study Indicates Significant Effect of Pressure on Resistivity of Reservoir Rock. C. R. Glanville. *J. Petrol. Tech. 11,* 20 (1959) Apr. (7 pp.)

Effect of overburden and fluid pressure on the resistivity of reservoir rock has been generally ignored in the quantitative interpretation of electrical logs. Article shows, from laboratory tests of two sandstone, two limestone and one dolomite formation, that theoretical reservoir stress increases resistivity in varying amounts, depending upon depth (or stress) of formation, porosity, texture of rock and degree of water saturation.

Drilling

Petroleum Technology in the USSR. I. S. Salnikov. *World Petrol. 30,* 43 (1959) Apr. (5 pp.)

Despite poor management and backup facilities, Russia's oil industry probably will raise production to almost 5,000,000 bbl/d by 1965. One of the problems lies in Russian drilling technology. As brought out in the form of recommendations in October, 1958, these problems include: 1) Reduction of bit sizes to 8- and 9-in. in diam., and subsequently to 6-in.; 2) expand application of electrodrill; 3) continue efforts to improve design, quality, variety and cost of new drilling bits; 4) improve quality and design of drill pipe; 5) design and make available a variety of rigs or deeper drilling and portable units for well testing; 6) make available aquagel, barytes and chemical agents for all general drilling purposes; 7) reduce size of hole drilled and quantity of casing used in oil well completions, and 8) provide better management and planning in delivery of equipment and supplies and adaptation of new equipment and drilling technology.

Drilling Muds

Extensive Field Tests Show that CMC Cuts Costly Packer Mud Problems. R. S. Baker. *Petrol. Eng. 31,* B-25 (1959) Apr. (3 pp.)

Special gel-CMC mud, consisting of bentonite, sodium carboxymethylcellulose (CMC), barite, caustic soda and water, is adaptable for many operations. It is a good mud to spot in the bottom of a deep hot well for logging or completing. Because of its low clay concentration, it is not readily damaged by contamination, making it suitable as workover mud. If contamination does occur, such as when cement is drilled, it can be successfully treated. More important, however, is its primary function as a packer mud.

Low-Solids Muds Score High. P. O. Pope and J. Mesaros. *Oil Gas J. 57,* 90 (1959) May 4 (6 pp.)

Report on drilling muds used in the world's deepest well and two others nearby (all drilled in Pecos County, Texas) and almost as deep. Three wells had almost every known drilling problem; still muds did good jobs. Basically, muds were designed and maintained as low-solids muds. Driscose was the primary mud material in all three. Treatment was based on the premise that Driscose would permit a mud to remain fluid and keep good flow properties in wells that were hot and deep. Premise was proved true and it is apparent that the oil industry does have a drilling fluid for deep wells.

Use High-Calcium Drilling Fluid to Stop Shale Hydration. P. H. Monaghan and J. L. Gidley. *Oil Gas J. 57,* 100 (1959) Apr. 13 (4 pp.)

Hydration of shaly materials causes trouble during drilling. Swelling and dispersion of clay minerals aggravate hole enlargement, formation sloughing and excess mud viscosity. Interaction between fresh water and swelling-type clays in producing sands permanently reduces well productivity. These difficulties can be prevented through the use of drilling fluids which inhibit clay hydration. Article reviews laboratory and field results with a drilling fluid containing 3000-4000 ppm soluble calcium. Four field tests of the high-calcium mud were conducted in an area in South Louisiana noted for troublesome shale problems. Drilling was at depths from 11,500-14,500 ft., and mud densities up to 16.5 lb./gal. were utilized. Results to date indicate a reduction in hole enlargement, improved drilling rate and less shale hydration. Mud had good stability under field conditions and was easily maintained by rig personnel.

Exploration

Continuous Seismic Profiler Aids Marine Exploration. C. B. Officer. *World Oil 148,* 107 (1959) Apr. (4 pp.)

Versatile new marine exploration device, known as the sparker or continuous seismic profiler, is essentially a continuous sound reflection device and is used for mapping geologic horizons to depths of 400-1200 ft beneath the ocean bottom. Results are recorded directly in the form of a geologic cross section which shows the sedimentary layers and geologic structures within the range of the instrument. Sparker offers both a separate and unique method of continuous surveying and a supplement to conventional surveying techniques.

Here Are Details of a Unique Magnetic Tape Playback System. H. H. Frost. *World Oil 148,* 123 (1959) Apr. (4 pp.)

Advent of magnetic tape recording of seismic records has led to development of equipment specifically designed to process such recording. Magnolia Petroleum Company's field research laboratory recently has developed an unusual magnetic tape playback system which incorporates 1) a multi-channel "time-shifter"; 2) a TV-type monitor, and 3) a "variable-area" type cross section writer. Results closely approximate a pictorial representation of a cross section of the earth. Excellent variable-area records are obtained with the system. Also, much of the drudgery of seismic computing is eliminated, which allows the interpreter to devote much more time to interpretation.

New Exploration Technique Shows Promising Results. R. Y. Walker and S. R. Litzenberg, Jr. *World Oil 148,* 134 (1959) Apr. (4 pp.)

Recently developed petroleum exploration technique provides valuable subsurface information for oil finders. Known as the emission technique, the procedure has been field tested in producing areas of Texas, Louisiana, New Mexico and Oklahoma for the past five years with good results. New exploration method is based on the emission and detection of low energy ("soft") gamma rays from the subsurface and the presence of hydrocarbons in formations. It is not concerned with the presence of structure or taps. Work also is effective in exploration of reef areas. Low energy gamma rays constantly are emitted from the subsurface and as they pass through an oil bearing formation, a certain percentage is retained by the hydrocarbon content of the formation. Surface instrumentation detects these emissions and records their intensity on a chart.

Nuclear Precession Magnetometer Successfully Field Tested. H. T. Brundage. *World Oil 148,* 127 (1959) Apr. (2 pp.)

Nuclear precession magnetometer may prove to be a very useful tool in oil exploration. Field use by several companies and a number of observatories, the latter in connection with the International Geophysical Year, indicates that this device is a reliable, durable, easily transported and adaptable instrument with a potential for improving magnetic exploration procedures significantly. Through its use, quantitative studies are being conducted to learn more about the complicated behavior of the earth's magnetic field. These studies are, in turn, bound to improve magnetic exploration by providing factors to compensate for diurnal changes which tend to impair accuracy of magnetic surveys.

Oklahoma Area Has Top Success Story. *Oil Gas J. 57,* 68 (1959) May 4. (2 pp.)

Wildcat success ratio for seven northwestern Oklahoma counties in that state's portion of the Anadarko basin is 52.3%. Operators have hit 34 times out of 65 tries; Beaver county has 14 successes out of 16 wildcats. Two latest finds in that county, whose 87.5% ratio breaks all previous records for wildcatting in any one Oklahoma county, were gas-condensate discoveries.

Plot Seismic Data with Electronic Computers. C. A. Wood. *World Oil 148,* 131 (1959) Apr. (3 pp.)

Electronic computers applied to plotting seismic cross sections offer interpreters increased accuracy and greater flexibility in representation of data. Preparation of these sections by hand techniques is laborious and time-consuming. Personnel sometimes become fatigued or bored. This may lead to computational errors and inaccurate plotting. The large number of repetitious operations involved in the tech-

nique made it a likely possibility for some type of automation. Method presented in article shows preparation of point-plotted cross sections using a digital computer and an accounting machine which has been modified to function as a plotting device.

Tidewater Hits on High-Pressure Test. *Oil Gas J. 57,* 66 (1959) Apr. 20 (2 pp.)

Tidewater Oil Co. has brought in a major gas-condensate discovery with a shut-in tubing pressure of 11,690 psi. This tops the 11,600 psi recorded in 1957 on a Union Oil & Gas Corp. well in the same South Louisiana area. The Tidewater well is the 2 Lascassane, about 10 miles southwest of Lake Arthur, La., in Cameron Parish, in Section 21-12s-5w. Nearest production is Chalkley field 4 miles to the west and South Thornwell field, 5 miles to the northeast.

Two Big Gassers Reward Northern Oil Hunters. F. J. Gardner. *Oil Gas J. 57,* 141 (1959) May 4.

Simultaneous discoveries of big gas at Petitot River and Kotcho Lake wildcats in northeastern British Columbia have emerged as the most important in Canada since Swan Hills in 1957. Both produce from Middle Devonian-Slave Point dolomite, correlative to the Swan Hills reservoir.

Weird Belgian Congo Gas Field Is Tapped. *Oil Gas J. 57,* 82 (1959) Apr. 20.

Unusual gas well has been flowing 100,000 CF/d from a well lowered into the pay zone without drilling. Moreover, the zone has 100% porosity, 100% water saturation and is not covered by impermeable rock. The flow has continued undiminished for 10 months through a plastic pipe supported by a floating platform. Science-fiction well is located 200 yards out from shore in Lake Kivu, a mountain lake in eastern Belgian Congo. It is producing from a zone of methane-saturated salt water. Layer is about 600 ft. thick and covers about 586 sq. miles. Gas is not underneath the lake bed but in the lake itself. Belgian engineers say more than 2 trillion CF of methane is indicated, out of a total of 8 trillion CF of gas.

Logging

Continuous Velocity Logger Yields Excellent Results. H. W. Hardy. *World Oil 148,* 111 (1959) Apr. (8 pp.)

Development of the continuous velocity logger promises to be an important contribution to exploration and production activities. Not only does the procedure represent a tremendous advance over the old technique of "shooting" a hole for velocity information, but it represents an excellent qualitative and quantitative porosity tool for geophysicists, geologists and production engineers.

New Slim Logger Runs through Drill Pipe. P. E. Chaney, F. M. Mayes, J. Bennett and J. W. Jones. *Oil Gas J. 57,* 112 (1959) Apr. 13 (2 pp.)

For many years, the industry has needed a tool to permit electric logging on a drill stem. Such a tool would: 1) Reduce logging cost because less rig time would be needed; 2) improve formation evaluation because freshly drilled formations could be logged before there had been much time for invasion by the drilling fluid; 3) reduce the hazard of losing the hole while logging because logging would be done without removing the drill string from the hole. Sun Oil Co. has developed and field tested such a logging tool. Device permits logging freshly drilled formation. It consists of a measuring and recording instrument body carrying at its lower end a long, flexible electrode assembly. To obtain a log, the tool is pumped down through the drill string with the instrument case coming to rest inside the drill collar. The electrode assembly is washed out through one of the mud passages in a jet bit into the open hole below.

Offshore Operations

New Muds and Techniques Improve Drilling Practices. J. A. Gill and W. M. Carnicom. *World Oil 148,* 194 (1959) Apr. (9 pp.)

New type muds and techniques are improving drilling practices in offshore operations in the area extending seaward from the coastline bordering the Louisiana parishes of Cameron, Vermilion, Iberia, St. Mary, Terrebonne, La Fourche, Jefferson, Plaquemines and St. Bernard. These advancements have 1) overcome hazards inherent in over-water operations; 2) satisfied planning requirements; 3) included an economical use of centrifuges and 4) included evaluations of various mud types for deeper drilling.

Recycling

'Ain Dar Gas-Injection Project. J. W. Barker. *Petrol. Eng. 31,* B-36 (1959) Apr. (3 pp.)

To conserve natural resources and to maintain reservoir pressure, the Arabian American Oil Company is installing a 200,000,000 CF/d gas-injection plant in the 'Ain Dar area of the Ghawar field in Saudi Arabia. Ground was broken in November, 1957, and completion was scheduled for the end of 1958. Over-all project, including pipelines, power lines, conversion of the gas-oil separator plants feeding the injection plant and miscellaneous work will cost approximately $30,000,000.

Reservoir Engineering

Field Test Confirms Accuracy of New Bottom-Hole Pressure Gauge. G. Lozano and W. A. Harthorn. *J. Petrol. Tech. 11,* 26 (1959) Feb. (5 pp.)

Maihak bottom-hole pressure gauges have been field tested in three wells in the San Joaquin Valley, Calif. These are the first known installations of this surface-indicating gauge in the U.S., although it has been used several years in Europe. The gauge consists of a transmitter located at the bottom of the tubing and a receiver at the surface. Signaling circuit consists of a single conductor wire strapped to the outside of the tubing itself. Measurements have been made successfully as deep as 6885 ft. The gauge, manufactured in Germany, appears accurate and reliable and should be a useful addition to the tools of the petroleum engineer.

Secondary Recovery

Application of Laboratory Data in Calculating the Primary Production History of the Cisco K-1 Reservoir. T.N. 2028. W.C. Hardy and B. W. McArthur. *J. Petrol. Tech. 11,* 61 (1959) Feb. (4 pp.)

Discussion of application of laboratory data in calculating solution gas-drive performance of the Cisco K-1 reservoir. Included is a diagram showing the graphical relationship between six variables common to all solution gas-drive mechanisms. With an iterative process one may assume existence of any of these six variables at a particular pressure and calculate the production performance likely to occur in a reservoir produced by solution gas drive. Four unique pressure values are described at which the material balance equation alone is sufficient to predict the cumulative volumes of gas produced. Information derived from these pressure points establishes a criterion for determining compatibility of the pressure-volume-temperature analysis of the produced crude with the gas production history. Two averaging procedures are used to arrive at a relative permeability-saturation relationship which describes the field-wide performance.

California Propane Flood Looks Good. *Petrol. Week 8,* 21 (1959) May 8.

Initial results of Standard Oil Co. of California's miscible phase displacement project in the Midway-Sunset field, Kern County, show production figures of 760 bbl/d for oil, 1051 bbl/d for water and 1, 019,000 CF/d of gas. When the project was initiated, production was 1100 bbl/d of oil, 650 bbl/d of water and 2,122,000 CF/d of gas. Figures are not representative of a true comparison because of the pool's normal decline and because wells with high gas-oil ratios have been shut in. Operator currently is injecting 50,000 gal/d of propane, split evenly between two injection wells.

In Situ Combustion Process—Results of a Five-Well Field Experiment in Southern Oklahoma. T. P. 8056. J. T. Moss, P. D. White and J. S. McNiel, Jr. *J. Petrol, Tech. 11,* 55 (1959) Apr. (10 pp.)

While this field of the *in situ* combustion process is perhaps most properly regarded as an extension of a laboratory research project because of its size and manner of operation, certain information basic to the process has resulted from the work reported. Whether the test pattern was sufficiently large to exhibit combustion and fluid-flow characteristics identical to those that will exist in larger well spacings has not yet been established. Probably the most important result of the test was the confirmation of laboratory-derived data for a particular reservoir by actual field experimentation. It now appears reasonable to expect that laboratory studies on other oil reservoirs should give useful design information, permitting at least an approximate appraisal of the oil recovery possibilities by *in situ* combustion for almost any particular oil field.

Laboratory Investigation of the Water-Driven Carbon Dioxide Process for Oil Recovery. D. M. Beeson and G. D. Ortloff. T. N. 2032. *J. Petrol. Tech. 11,* 63 (1959) Apr. (4 pp.)

Water-propelled banks of carbon dioxide recovered both high- and low-viscosity crude oil substantially in excess of that recovered by water flood in linear flow model experiments. Increase in oil recovery is explained by oil swelling and viscosity reduction. Additional oil was recovered by solution gas drive at the end of the carbon dioxide floods when the model systems were depressured.

Well Practice

Bottom Hole Separators Increase Production. W. P. Schmoe. *World Oil 148,* 152 (1959) Apr. (5 pp.)

Continental Oil Co. has realized considerable success with bottom hole separator installations in wells in the Denver-Julesburg and Powder River basins of the Rocky Mountain area. Separator is a relatively new tool designed to economically increase pump efficiency and, in turn, increase well productivity in gassy wells. In some cases it will increase ultimate recovery by reducing the gas-oil ratio and thereby help prevent waste of reservoir energy. Because of the uniform production of separator-equipped wells, it may be possible to pump low-volume producers continuously without excessive stuffing-box troubles, thereby further increasing potential. This characteristic also may result in more accurate gas measurement, thereby improving production allocation and reservoir data. Also, it has, in some cases, reduced orifice meter maintenance.

By utilizing well tests, pulling records, dynamometers and sonic liquid level devices in selecting wells for separator installations, a success ratio approaching 100% can be obtained.

How to Save with Tubingless Completions. C. B. Corley, Jr. and J. L. Rike. *Oil Gas J. 57,* 84 (1959) Apr. 20 (5 pp.)

Fundamentally, tubingless completion is miniaturization applied to oil and gas wells. Wells are cased with pipe as small as 2⅞ O.D. In many cases no inner string of tubing i necessary for production. This has caused the name, "tubingless completion." Except for size of the equipment, basic difference between the tubingless completion and conventional wells is the absence of an inner retrievable tubing string.

Drilling

Hydraulic Turbine with By-Pass Valve. F. Whittle (assigned to Shell Development Company.) U.S. 2,879,032 (1959) Mar. 24.

By providing a drilling mud bypass between the hydraulic turbine and the bit, which is a double radial cylinder and piston device, the flow of fluid is made to control the weight on the bit and permits more uniform load whether hard or soft formations are drilled.

Secondary Recovery

Gaseous Hydrocarbon and Carbon Dioxide Solutions in Hydrocarbons. J. W. Martin, F. A. Hessel, I. P. Hammer and J. B. Rust (assigned to Oil Recovery Corp.) U.S. 2,875,832 (1959) Mar. 3.

Improved methods of recovering liquid hydrocarbons from formations is claimed which comprises injecting a mixture of carbon dioxide and a predominantly hydrocarbon (C_2-C_4) gas at 150-500 psi and 27° C, the CO_2 being in 2:1 ratio, to contact the liquids in the formation. The CO_2 causes an increase in solubility of the gaseous hydrocarbons in the crude oil so that the oil has a reduced viscosity, surface tension and specific gravity and is more readily released from formation.

4. GAS CONDITIONING AND LPG RECOVERY

Carbon Dioxide Removal

Two Processes Unveiled at NGAA. *Oil Gas J. 57,* 92 (1959) Apr. 27.

Italy's gas-treating procedures for removing carbon dioxide and hydrogen sulfide from natural and synthesis gas were introduced at Dallas meeting of the Natural Gasoline Association of America. With the processes 1) carbon dioxide can be extracted from gases relatively free of hydrogen sulfide and 2) selective hydrogen sulfide removal can be effected. Savings brought about by using the new processes instead of conventional gas-treating processes amount to 30-60% in some cases. Both processes are named Giammarco-Vetrocoke in honor of their developer, G. Giammarco of S.p.A. Vetrocoke, in Italy.

The Giammarco-Vetrocoke Process for Acid-Gas Removal. F. C. Riesenfeld and J. F. Mullowney. *Oil Gas J. 57,* 86 (1959) May 11 (6 pp.); **For Acid Gas Removal . . . Giammarco-Vetrocoke Processes.** *Petrol. Refiner 38,* 161 (1959) May (8 pp.)

Two distinct processes, one for the removal of CO_2 from gases essentially free of H_2S and another for selective H_2S removal, are based on the absorption of acid gases in an alkaline solution containing inorganic or organic additives. Typical inorganic additives used in the CO_2 absorption process are arsenic oxide and selenious and tellurous acid. Effect of the additives is primarily an increase in the rate of absorption and desorption of CO_2 resulting in significant savings in plant cost and utility consumption. Sodium and potassium carbonate solutions containing tri and pentavelent arsenic are used in the H_2S-removal process. This process can be made entirely selective fo H_2S in the presence of CO_2 under conditions of temperature and pressure not feasible with presently known processes. Articles describe both processes, comparing each with other processes. Process economics are detailed, and it is pointed out that in order to take full advantage of the flexibility and many variations possible with the G-V processes, a careful economic analysis of each individual project is necessary. This is particularly true for cases involving H_2S removal where such factors as gas impurities and treating temperature must be considered.

Condensate

Remote Control of a Gas-Oil Separator Plant. J. A. Conneran. *World Petrol. 30,* 41 (1959) Apr. (2 pp.)

Conventional gas-oil separator plant is constructed at a cost of about $1,500,000. The additional $200,000 required investment to convert one of these plants to remote control is justified in several ways. By integrating the base-station operation into the control room of an existing facility, the investment will pay out in several years. Although the remote control equipment involves additional maintenance functions, the substantial savings in operating costs results in a net saving. Operating labor costs at a remotely located plant are high because of high

backup costs for services and housing facilities. The operator relieved of assignments at remote stations will be more profitably used at central plants.

Condensate Removal

Canada's New Peace River Natural Gas Plant. J. Grindrod. *Petrol. 22,* 181 (1959) May (2 pp.)

Claimed to be unique because of its size and the diversity of its processing facilities, the new £11-million McMahon gas scrubbing and refining plant at Taylor, B.C., some 650 miles northeast of Vancouver, has recently been placed in operation. It is treating Peace River natural gas before delivery to Westcoast Transmission Ltd. for piping through B.C. and the U.S. Pacific Northwest. Refining facilities cover the separation of the condensate from the sour wet natural gas gathered from the wells in the area, the sweetening and dehydration of the gas, the extraction of recoverable hydrocarbons and their conversion into propane, butane, motor and aviation fuels, kerosene and diesel oil.

Dehydration

How to Use Molecular Sieves for Natural-Gas Treating. E. L. Clark. *Oil Gas J. 57,* 120 (1959) Apr. 27 (4 pp.)

In natural-gas drying, molecular sieves can provide twice the dehydration capacity of conventional desiccants while providing longer life. In natural-gas sweetening, progress has been achieved in developing a molecular-sieve process using a single-stage rapid-cycle drying and sweetening unit.

Dust Removal

Dust in Gas Streams. Part 3-A. Sampling Techniques and Errors. A. W. Doyle, N. M. Wiederhorn and A. Swan. *Am. Gas J. 186,* 28 (1959) Apr. (5 pp.); Part 3-B. **Recommendations for Sampling.** *Ibid.,* 57 (1959) May (3 pp.)

Numerous sampling procedures are employed by the various companies within the A.G.A. These companies are accumulating information on standardized equipment. If data taken with this equipment are to be directly comparable, sampling procedures must also be standardized whenever possible and any inherent errors understood. In any gas sampling system there are several possible sources of error: 1) At the entrance to the sampling nozzle, where the linear velocity may differ from that of the line; 2) at bends in the sampling line where impaction and subsequent loss of particles may occur; 3) at the walls of the sampling probe, where losses by diffusion of the particles may occur; 4) in vertical sections of the tubing, where the velocity may be insufficient to support the particle; 5) in horizontal sections of the tubing, where particles may settle; 6) because of the introduction of spurious liquid particles; 7) because of the diameter of the probe nozzle; 8) probe direction, and 9) probe location in duct. In Part 3-A, these errors are discussed and techniques of obtaining a "true" sample of the dust laden particles in the gas system are presented. Recommended sampling system is the topic of Part 3-B, and a tubular summary of sampling errors showing type of error introduced, particle size concerned, importance of effect and action for best sampling is included.

Gasoline

Journal Survey Shows Little Change in Operation of Nation's Natural-Gasoline Plants. *Oil Gas J. 57,* 124 (1959) Apr. 27 (16 pp.)

According to latest survey, there are 488 operating natural-gasoline plants in the U.S., exactly the same number as last year. Plant capacity is up from 24.8 MMCF/d to 28. Since many companies prefer not to disclose their throughputs, this column was not totaled this year. Plant products increased as follows: Combined natural gasoline-LPG stream, 10.6 million gal/d to 11.1; total butane and lighter 12.6 to 13.5; natural gasoline, 8.6 to 8.2 (decrease), and liquids heavier than natural gasoline 554,000 gal/d to 663,000. Sixteen pages of graphs indicate where U.S. natural-gasoline plants are located, what they produce and how much.

Hydrates

Prevention of Natural Gas Hydrates by Freeze-Out Method. Y. P. Korot, G. S. Lutoshkin and N. I. Nam. *Gazovaya Prom.,* 11 (1959) No. 4 (5 pp. Russian text.)

Refrigerating effect obtained by throttling the flow of natural gas is used to cool the gas in intermittently operating heat exchangers to form hydrates under conditions which permit their removal. A pressure drop of from 140 to 65 atms will cool 30,000 m^3/hr of natural gas from 30°-7.5° C and remove 6.9 kg of water/hr (equivalent to 7.8 kg of $CH_4 7H_2 0$). This method is less expensive than the use of methanol. J. W. Penney

Carbon Dioxide Removal

Method of Deacidifying Gases. W. Breuing and R. Spolders (assigned to Firma Ruhrstahl AG.) U.S. 2,878,099 (1959) Mar. 17.

Economical removal of acidic gases, such as CO_2 and H_2S, is claimed by a two-stage washing process, in which ammonium salt solution (formed in the second stage) is used as washing liquid in the first

stage to remove part of the CO_2 or H_2S by forming the acid salt, and ammonium hydroxide wash is used in the second stage to remove final traces of CO_2 or H_2S. The acid salt solution from the first stage is regenerated by continuously withdrawing a portion and boiling to remove CO_2 and H_2S as gases and recirculated the regenerated ammonium hydroxide to the second stage.

Hydrogen Sulfide Removal

Method of Simultaneously Removing Hydrogen Sulfide from Gaseous Mixtures and Producing Sulfur Therefrom. F. M. Townsend (assigned to Laurence S. Reid.) U.S. 2,881,047 (1959) Apr. 7.

Hydrogen sulfide is removed from fuel gases by scrubbing with a 90% concentrated aqueous glycol. The glycol is saturated with sulfur dioxide which reacts with H_2S to form sulfur. Sulfur may be recovered by settling, filtering or melting.

Method of and System for Recovering H_2S from Natural Gas Containing a High Percentage of H_2S. E. B. Miller (assigned to Jefferson Lake Sulphur Company.) U.S. 2,877,861 (1959) Mar. 17.

Continuous cyclic absorption process is claimed for removing hydrogen sulfide from natural gas, in which a series of absorbing beds are rotated between an inlet and an outlet disc valve manifold of tube-sheet type. Each bed is successively held in a position which permits passage of gas to be purified, purge gas and hot activation or stripping media during one rotation.

5. NATURAL GAS TRANSMISSION

Automation

Digital Data Handling Techniques of Telemetering in Integrated Systems. L. K. Hedding. *Pipe Line News 31,* 39 (1959) Apr. (5 pp.)

Obvious features of an integrated systems design are: Both maximum security and maximum reliability are achieved; lowest possible operational costs through use of a single telegraph grade communication channel for the operation of a very extensive control and data handling system; facilitation of multi-station coordination where there are several fields to be controlled; maximum utilization of the system's components where dual or multiple functional usage can be realized, and acquisition and storage of data in digital form compatible with the third stage of this evolutionary process, namely, the future usage of this data with business machines and computers, both for complete system operational automation and for automation of those operations requiring utilization of the data for accounting, billing and other business procedures.

How World's First Pushbutton Gas Pipeline System Works. D. G. Emmel. *Petrol. Eng. 31,* D-24 (1959) Apr. (3 pp.)

Columbia Gulf Transmission Company, Nashville, Tenn., recently turned switches which placed the first of five 14,000-hp automatic stations . . . each some 180 miles apart on an 841-mile main line . . . on completely unattended remote operation from a central location. First automatic station is at Hartsville, Tenn. Within a matter of days, three additional stations, at Stanton, Ky., Corinth, Miss., and Alexandria, La., also become unattended remote stations. For the first time in natural gas transmission history, it became possible for one man to monitor and control the flow of gas through an entire pipeline system.

Soon . . . Automatic Control without the Button Push. E. N. Sampson. *Petrol. Eng. 31,* D-32 (1959) Apr. (2 pp.)

Automatic sequenced compressor units started by the depression of a button are now in service. Closer than realized are automatically controlled units that do not require the push. Control systems already have been designed that do not require a manually initiated starting signal or running control. Among gas pipeline and controls people, a unit that can be properly started by actuation of a pushbutton or turning of a selector switch is considered as having "automatic sequence control"; one that starts from a set point or predetermined condition occurring with actuating a pushbutton is considered "automatic."

Step toward Automation. K. C. Yost. *Gas 35,* 117 (1959) Apr. (7 pp.)

Automatic system must accomplish safely the same functions that personnel would perform at a measuring station. Safe functioning has been accomplished to the extent that nonintentional equipment operation is highly improbable. Loss of telephone lines, power failure or equipment failure will not cause involuntary operation of the equipment. Telemetering of information will, of course, be lost, but the flow will remain in the last operated position until repairs have been completed. Loss of supply gas to the controller or diaphragm rupture on control valves will result in the valves falling open. Necessary information may be presented to the dispatcher in such a manner as to increase the efficiency of operation of the gas transmission system. This means of controlling the flow of gas is also provided to insure rapid and accurate allocation of gas through the transmission system.

Communications

Microwave Occupies a Key Position in Pipeline Operations. P. A. Smith and L. Weddig. *Petrol. Eng. 31,* D-36 (1959) Apr. (3 pp.)

Growth of microwave was a natural evolution of wireline communications media. As the requirement developed for more communications facilities, carrier equipment permitted combining many communications over a single wire line by use of multiplexing techniques—combining many channels of intelligence at the sending end, separating them at the receiving end. Using a narrow, highly directive radio frequency beam instead of wires was the next step. This development of microwave techniques, especially in the 6000-mc frequencies, is a post World War II occurrence. Efficient, successful microwave communications have resulted with many systems in the pipeline and petroleum-gas operating areas carrying three to more than 20 channels of intelligence.

Overcoming Coordinating Problems in a Radio System. O. H. Johnson. *Gas 35,* 68 (1959) Apr. (4 pp.)

Northern Illinois Gas Co.'s two-way mobile radio network, described as one of the most complex utility systems in the country, operates in three frequency bands. It utilizes mobile repeater, selective signaling, single tone base station control, and tone coded squelch techniques, among others, to overcome design problems caused by necessary frequency coordination. Because of the coordinating problems encountered, the system design was the result of attempting to make the best possible use of available frequencies rather than one that would best suit the company's purposes if the coordinating problem did not exist.

Compressor Stations

Automation of Compressors. D. P. Corkill. *Pipe Line News 31,* 22 (1959) Apr. (2 pp.)

Northern Natural Gas Company made its first major step toward compressor station automation in 1953-54 when it installed two new gas turbine compressor stations with a total of eight units and control panels, and added one vertical reciprocating gas engine and controls at an existing compressor station. On these installations, the equipment is so assembled that any of the machines can be automatically started and brought up to operating speed by turning one control switch. In addition, the machines are continuously monitored by protective and corrective devices to make control changes as the operating conditions change on the engine and provide warning and/or shut-down as required if the operating conditions exceed safe limits.

Making Compressor Stations Quiet Enough to Live With. W. J. Severin. *Oil Gas J. 57,* 96 (1959) May 4 (4 pp.)

Noise problems connected with the transmission of natural gas have multiplied considerably in the past 10 years and the noise levels experienced have become quite severe. Recent court decisions favorable toward workers who suffer partial loss of hearing and the apparent loss of worker efficiency due to fatigue have also stimulated management to study noise problems. Article deals primarily with compressor-engine noise and ways of abating it.

Texas Eastern Finds Satellite Stations Successful. *Oil Gas J. 57,* 96 (1959) Apr. 27. (2 pp.)

Four remote-controlled compressor stations, powered by the largest gas turbines ever used for natural-gas transmission, have completed their first winter's run with outstanding success. Satellite stations are located on Texas Eastern Transmission Corp.'s Penn-Jersey system near Armagh, Entriken, Shermans Dale and Bernville, Pa. They are remotely controlled from the downstream control stations of Lilly, Grantville, Perulack and Bechtelsville, Pa. Each satellite is equipped with a single 13,400-hp gas turbine driving a two-stage centrifugal compressor at 4860 rpm. Satellite and its control station are tied together with two pairs of leased common-carrier lines, one for transmission of control signals and the other for transmission of alarm and telemeter information back to the control point.

Fluid Flow

Measurement of the Flow through a Pipeline by Measuring the Pressure at a Single Point. A. D. Altschul. *Izmerit. Takhnika,* 40 (1956) No. 3 (3 pp. Russian text); *Ref. Zh. Mekh.* Rev. 6641 (1956) No. 6. (From *Appl. Mech. Rev. 12,* 273 (1959) Apr.)

Results of special tests are presented, showing that the divergence in the values of the mean velocity determined by the "uniflow" method and by measuring the mean velocity at eight points on the cross section should not exceed 4%. It is remarked in this connection that perceptible deviations in the position of the point selected for measuring the mean velocity from the theoretical values given produce only small variations in the magnitude of the flow volume measured. Author explains this by reference to the existence in the literature of different recommendations concerning the position of the point of mean velocity.

V. I. Gotovtsev
Courtesy *Referativnyi Zhurnal,* USSR
Translation, courtesy Ministry of Supply, England

Gas Turbines

On Great Lakes Line . . . Gas-Fired Turbine Is Working Out. *Pipe Line Ind. 10,* 45 (1959) Apr. (3 pp.)

Early in 1958, Great Lakes Pipe Line Company installed a 1150-hp gas-fired turbine on its new 12-in. Tulsa-Barnsdall line. Turbine drives a single-stage, double-suction pump built especially for this service. At full capacity, it will handle 3950 barrels of products/hr discharging at 630 psi. This capacity is the equivalent of two 6-cylinder diesel engines, each driving three-stage pumps on the company's other 12-in. Tulsa-to-Barnsdall line. Actually the turbine-driven pump has gone as high as 4200 bbl/hr. Small size turbine may prove popular on other products line.

Metering

Evolution of the Vortex-Velocity Gas Meter. B. J. Caldwell. *Gas 35,* 124 (1959) Apr. (8 pp.)

Vortex-Velocity meter, recently introduced to the gas industry, operates on the following principle: Gas flowing through the pipe creates a natural eddy in the offset cylindrical chamber. Rotation of this whirlpool or vortex is proportional to the main flow through the pipe. There are equations that prove this statement to the hydraulic engineer. A squirrel cage rotor is mounted in the cylindrical chamber to ride with the vortex as a counter of its rotation. Requirements of counting the rotor revolutions are met with a magnetic coupling. A cylindrical magnet on the rotor shaft transmits through a thin, but strong, non-magnetic hub to another outside magnet on a counter or transducer shaft. This imposes a small torque on the motor.

Pipeline Construction

Building the Pipeline to Sunshine. J. F. Ebdon. *Gas 35,* 107 (1959) May (20 pp.)

Comprehensive, well-illustrated story of construction of both the Coastal Transmission and Houston Texas Gas segments of a pipeline system whose purpose is to pick up natural gas in producing areas in the Texas-Louisiana Gulf Coast and move it to Florida for delivery. Initial system is designed to deliver an average of 282 MMCF/d with a maximum day delivery of 286 MMCF at 14.65 psia and 60° F and based on 1000 Btu/CF natural gas (dry basis) but future expansion will deliver 411 MMCF on an average day. As initially constructed and operated, the mainline will total 1476.5 miles of 12-in. through 24-in. OD steel pipe. Some 1087.9 miles of supply and delivery laterals from 2.5-in. nominal diam. through 18-in. OD will be constructed to make an approximate total of 2564.4 miles of pipe in the transmission system. Article discusses facilities, gas sales, gas supply, contruction phase, protective coating and other features, includes table on cost of initial project and pictorial descriptions on pipe laying techniques, terrain and tape wrapping operations, and includes schematic on gas flow, oil flow, air flow, water flow and an engine gauge board at one installation.

Electrical Survey Detects Underground Rock. H. E. Barnes. *Pipe Line Ind. 10,* 43 (1959) Apr. (3 pp.)

Contractors may be able to better estimate the costs of ditching with resistivity survey described which not only indicates the presence of clay, rock, etc., but also shows depth.

How Russians Saved 290,000 Rubles on River Crossing Job. A. J. Steiger. *Pipe Line Ind. 10,* 48 (1959) Apr. (4 pp.)

Russian report gives a step-by-step account of how a pipeline about 28-in. diam. and almost 600 yards long was laid across the Yenisei River at Krasnoyarsk in Siberia during the midst of winter at temperatures reaching —30° F. Construction work was done from January to March, and ice-bound river supported all pipeline operations which included digging an underwater trench with draglines, welding pipe sections together into a river-wide span and lowering the welded line from the ice into the underwater trench. Savings accrued with this method amounted to almost 300,000 rubles.

Pipeline Systems

Computer Evaluates Design of Gas-Gathering System. L. R. Henry and R. B. Peritz. *Oil Gas J. 57,* 89 (1959) Apr. 20 (3 pp.)

Problem of determining pressures in a gas-gathering system is of continuing interest in the natural-gas industry, and in the past has proved very troublesome. Use of high-speed digital computer in solving this problem has now been proved practical, and can be considered a common engineering-department procedure rather than a developing technique in research. Article shows two typical gathering-system designs. One consists of 204 miles of pipeline serving 181 wells, totaling 240,000 MCF/d. Other has a large loop line across the entire field. Several programs for the IBM 650 computer have a combined limit of 1000 total sections, whether lateral or loop, and a maximum of 498 loop sections, arranged in not more than 46 loops. This is more than adequate for most gathering systems. There is no explicit limit on the number of wells possible to make up a field, though usually there is an average of one section for each well.

Telemetering

How Roanoke Gas Profits from Telemetering. A. W. Buckley. *Gas Age 123,* 29 (1959) Apr. 2 (3 pp.)

Roanoke Gas Company serves the cities of Roanoke, Salem and Vinton, Va., having a population area of 130,000 people, located in the southwestern extremity of the Shenandoah Valley. Roanoke Gas serves about 18,500 customers, with approximately 60% heating saturation. During the winter months, when the company's telemetering equipment is put to utmost use, it can expect unusual combinations of weather due to the mountainous location, such as snow, relatively cold temperatures, prolonged cloud coverage and high winds. During these varying load conditions, telemetering assumes a very important role in the company's operation.

Make Telemetering System Flexible. D. E. York. *A.G.A. Monthly 41,* 29 (1959) Apr. (6 pp.)

Each company should exert every effort to analyze its telemetering problem and to design a system that may be adapted to many changing conditions. As a first step toward this goal, a committee can be organized composed of people who are responsible for planning a company's future. A typical committee might have representatives from transmission, compressor, production, staff engineering, gas measurement, gas dispatching, distribution and communications. Committee should be under the guidance of someone with a technical knowledge of available equipment and its application to carry out the plan of the committee.

Telemetering in Northern Ontario. E. E. Bagley. *Gas 35,* 76 (1959) May (4 pp.)

Northern Ontario Natural Gas Co. Ltd. finds its telemetering system vital to maintain high load factor, to stay within daily contracted demand and to observe system operating pressures. Considerations of rugged terrain, costs, mineral deposit interference over the 1165 miles extending from Kenora to Orillia, Ontario, northern atmosphere interference, etc., led to the decision to employ electrical impulse time sign system and to use leased wire facilities. System installed has three circuits, employing self-synchronizing time multiplexing equipment and is capable of transmitting 45 signals. However, present plans are for 32 signals transmitted from 16 points. Company and affiliated presently serves 4300 customers a maximum daily demand of approximately 73 MMCF of natural gas. With distribution system construction completed in December 1958 and the gas dispatch section accurately projecting volumes of this size, company feels it has made the first step to effective gas sale and purchase control.

6. GAS AND LPG STORAGE

Liquefaction

Plant Finds Cold Storage Is Safer Storage for Liquefied Gas. *Chem. Eng. 66,* 76 (1959) Apr. 6 (3 pp.)

Columbia-Southern Chemical Corp., Natrium, W. Va., has disclosed features of chlorine storage facilities that are believed to be the safest in the world. Secret behind the achievement—safe storage of 2000 tons, or more than 300,000 gal—is to store the chlorine as a refrigerated liquid at atmospheric pressure. Much of the development work under way on marine transportation of liquefied gas incorporates the same principle.

Underground Storage

Distribution and Storage of Ethylene. W. H. Litchfield, W. H. LeGrand, M. Martin, D. C. Scheline and V. N. Hurd. *Chem. Eng. Progress 55,* 68 (1959) Apr. (6 pp.)

Ethylene will not liquefy at the temperatures prevailing underground, but pressures of 1000-2000 psi can easily be held in the salt cavities, giving an ethylene density approaching liquid density. No contamination of the ethylene is possible since hundreds of feet of inert salt separate the ethylene from the natural gas outside the dome. Gulf Oil Corporation now has four storage wells in the Fannett (Texas) dome—two for ethylene, one for propane and one for butane. These wells are placed near the center of the dome where the top of the salt is about 2000-2200 ft below the surface. Each well is about 1000 ft long and of 5-80 ft diam, with the tops of the wells about 2900 ft below the surface. Selection of these particular depths was somewhat arbitrary.

Effect of Unsteady-State Aquifer Motion on the Size of an Adjacent Gas Storage Reservoir. T.P. 8049. D. L. Katz, M. R. Tek and K. H. Coats. *J. Petrol. Tech. 11,* 18 (1959) Feb. (5 pp.)

In natural gas storage operations, seasonal pressure fluctuations in the gas reservoir cause the water from the surrounding aquifer to flow into and out of the gas sand. Theory of unsteady-state liquid flow through porous media developed by van Everdingen and Hurst has been applied to predict the water movement into and out of the gas bubble for several postulated pressure cycles. Those cycles with as many pound-days above the original aquifer pressure as pound-days below may cause the gas reservoir to slowly grow or shrink rather than hold to a constant volume. Applications to an actual field case study give the predicted gas reservoir monthly pressures and volumes as compared with the observed monthly pressures and volumes.

An Underground Storage Pool Takes Form. *Petrol. Eng. 31,* D-48 (1959) May (3 pp.)

Storage facility, known as Todhunter terminal, is being constructed for Texas Eastern Transmission Corporation, (La.) near Middletown, Ohio. When placed into service next fall, it will have a capacity of some 18,900,000 gal with provisions for expansion as the need arises. Terminal will be used to receive store and distribute LPG by truck and rail over a wide range of states from Michigan to New England. Caverns at Middletown will be similar to underground storage facilities for LPG already in use at Crossville, Kankakee, Tuscola and Eola, Ill., Marcus Hook, Pa., Siloam, Ky., Bayway, N.J., and many locations in Texas, Louisiana, Oklahoma and Mississippi. Underground caverns are considered ideal facilities for storage of LPG both from the standpoint of safety and economy.

Underground Storage

Ammonia Storage and Recovery System. J. E. Cottle (assigned to Phillips Petrol. Co.) U.S. 2,878,165 (1959) Mar. 17.

Invention provides an improved system for storage of ammonia in salt caverns and the recovery of ammonia therefrom. Deposition of salt from the recovered ammonia is prevented by use of a pressure fractionating column at 235 psig and 410° F bottom temperature, with water or steam injection to column trays just above ammonia solution feed; and cooling dilution water added to bottom outlet line. Anhydrous ammonia is recovered from top of column.

Underground Storage of Liquids. C. T. Brandt (assigned to Phillips Petroleum Company.) U.S. 2,879,646 (1959) Mar. 31.

Improved underground storage container for liquids (LPG) lighter than the sealing water is formed in a pervious rock formation lying between two impervious strata. A defined volume of pervious formation is encircled by a narrow tunnel, connected to the surface by a shaft, and extending from the floor to the roof. The outer wall is coated to retard fluid flow. At a spaced distance from the outer wall an annular membrane is suspended from the upper impervious layer sealed in the tunnel, with its lower edge a set distance from the bottom impervious layer. With water filling the tunnel and pervious layer to a level above the lower edge of the annular membrane, the immiscible fuel is pumped into pervious strata through a central cased wall. The fuel forces the sealing water downward in the strata and out into the tunnel and upwad into the water shaft. To withdraw fuel, water pressure from a standpipe forces a rise in level in the formation and pushes LPG up the central well.

7. MANUFACTURED GAS AND CHEMICAL PROCESSING

Carbonization

The New Plant of the B.C.R.A. Provides Test Facilities on a Normal-Practice Scale. *Gas J. 298,* 22 (1959) Apr. 1 (5 pp.); **B.C.R.A. Research Centre.** *Gas World 149,* 698 (1959) Apr. 11 (5 pp.); **The B.C.R.A. Coke Research Centre.** *Coke and Gas 21,* 134 (1959) Apr. (8 pp.); **Test Plant in Operation at the New B.C.R.A. Centre.** *Gas Times 43,* 49 (1959) Apr.

New test plant at Wingerworth, England, provides facilities for the carbonization of coal on a scale directly comparable with normal coke oven practice, and consists of one-full size silica coke oven, complete with regenerative heating system and byproduct plant. Comprehensive blending equipment is installed and provision is made for the special pretreatment of the coal. General workshop laboratory contains test ovens of smaller sizes and also provides accommodation for special projects which might be undertaken in the future. An engineering workshop also is housed in this building.

Catalysts

Studies of the Fischer-Tropsch Synthesis. XVIII. Influence of Catalyst Geometry on Synthesis on Iron Catalysts. J. F. Schultz, M. Abelson, K. C. Stein and R. B. Anderson. *J. Phys. Chem. 63,* 496 (1959) Apr. (5 pp.)

Influence of catalyst geometry on activity of reduced and reduced-and-nitrided fused iron catalysts in the Fischer-Tropsch synthesis was studied by the Bureau of Mines by varying 1) the particle size, 2) the depth of reduced layer and 3) the average pore radius. For catalysts reduced at 400 and 450° the activity curves may be approximated by assuming that only the outer layers of the particles to a depth of 0.01-0.02 cm are active. When the average pore radius was varied, the activity of 6- to 8-mesh particles remained essentially constant, despite the fact that the surface area varied in an inverse manner to pore radius. Apparently the depth of effective catalyst increased sufficiently to compensate for the decreased surface area. Changes in the composition of the catalyst during synthesis and product distribution are considered with respect to a simplified picture of transport phenomena in pores.

Coal Chemicals

Beckton's By-Products. *Gas World 149,* 734 (1959) Apr. 18 (4 pp.)

Review of history, growth and economic effects of byproduct recovery at the Beckton (North Thames Gas Board) gasworks.

Coal Combustion

Testing an Air-Cooled Slag-Tap Vertical Combustion Chamber. L. A. Bogdanov and B. D. Katznelson. (Trans. from *Teploenergetika,* 14 (1958) No. 11 (7 pp. Russian text.) *Combustion 30,* 57 (1959) Apr. (6 pp.)

Article presents constructional peculiarities and test results of a special stand, working under a pressure of 4 atm abs and using powdered coal. In this type of installation the use of a large quantity of water as a cooling agent for the cyclone combustion walls is undesirable. The combustion chamber in which the powdered coal burns operates on an open cycle. These installations are further peculiar in that they require the burning of the fuel under very high pressures.

Coal Gasification

The Gasification of Solid Fuels under Pressure. O. Hubmann. *Brennstoff-Chemie 40,* 65 (1959) Mar. 18 (7 pp. German text.)

General review of the development of the Lurgi pressure gasifier, from the basis of Drawe's and Danulat's work and results of the wartime Böhlen and Brüx installations. More recent advances in the Dorsten, Sasol, Morwell and Pakistan plants are described, with operating data given for the first three, and with mention of further applications in chemical and fertilizer synthesis.

New Results with Pressure Gasification of Coals in the Gas Plant of Steinkohlengas AG, Dorsten. H. Weittenhiller. *Brennstoff-Chemie 40,* 73 (1959) Mar. 18 (3 pp. German text.)

New development in operating procedures at Dorsten has effected great economies in gas production. This consists of reducing the water-cooling in the grate or replacing with steam cooling from a jacket-stream which is then injected from the grate as a gasifying steam. Temperature is reduced to just above the ash-slagging point.

Pressure Gasification of Fuels. H. Pichler, *Brennstoff-Chemie 40,* 71 (1959) Mar. 18 (3 pp. German text.)

Coal gasification processes currently under development in parallel with the Lurgi process are discussed and compared to the latter process. These include Fischer-Tropsch variants, Koppers-Totzek, U.S. Bureau of Mines, the Texas Company and Institute of Gas Technology.

Coal Hydrogenation

The Reaction of Carbon with Hydrogen at High Pressure. J. D. Blackwood. *Australian J. Chem. 12,* 14 (1959) Feb. (15 pp.)

Study has been conducted of the reactions of a number of carbons with hydrogen at pressures up to 40 atm and in the temperature range 650-870° C. Effect of total pressure and hydrogen partial pressure has been examined and the rate of methane formation for a given carbon formation can be expressed as rate $= kp_{H2}$. Values of log k when plotted against $1/T$ give a straight line and the "apparent" energy of activation is approximately 30 kcal mole^{-1}. Value of the constant k for a given temperature of reaction is dependent on the oxygen content of the carbon which is, in turn, dependent on the temperature of preparation of the carbon. For carbons containing no oxygen, the methane rate is zero. Oxygen appears to be associated with at least two types of active centers. One type, considered to have a lactone structure, is responsible for an initial rapid evolution of methane and water and is destroyed during the first few minutes of hydrogenation. The other center, responsible for the slow steady evolution of methane, appears to be associated with structures such as chromene or benzpyran which activate certain sites on the carbon crystallite. Neither steam nor carbon dioxide will activate the carbon for the formation of methane.

Gasification

Gasification of Siberian Brown Coals Using an Oxygen-Enriched Steam-Air Blast. G. N. Khopta. *Gazovaya Prom., 11* (1959) No. 1 (6 pp. Russian text.)

As a result of pilot plant tests at pressures of 5-18 atms, and with oxygen contents in the blast of from 21-100%, the author determined the effect of oxygen concentration on thermal value of product gas, inert content of gas, fuel requirements, gas composition, and steam decomposition. With 100% oxygen, the product gas was 9% CH_4, 15% CO, 33% CO_2, and 43% H_2, calorific value was 2800 kcal/m^3 and steam decomposition was 47%.

J. W. Penney

Inert Gases

Application of the Endothermic Atmosphere Generator to the Sintering of Powder Metal Parts. N. K. Koebel. *Ind. Heating 26,* 692 (1959) Apr. (7 pp.)

Endothermic type of atmosphere is being used throughout the powder metal industry for high production sintering because it enables controlled carbon potential for iron powders, has highly reducing composition without the need of purification equipment or dryers for non-ferrous powders, is inexpensive ($.18-$.25/MCF) and is easily produced from inexpensive fuels.

Oil Gas

The Pyrolysis of a Heavy Crude Oil in a Fluidized Bed. G. G. Madgwich, C. H. Amberg and W. S. Peterson. *Can. J. Chem. Eng. 37,* 65 (1959) Apr. (6 pp.)

Pyrolysis of a heavy high-sulfur crude oil in an inert fluidized bed at temperatures between 550-800° C has resulted in the production of an olefin-rich gas and a liquid product containing increasing amounts of aromatic material with increasing temperature. Analysis of the process gas has shown that for average reactor residence times of more than one second, equilibrium is approximated for the system ethane-ethylene-hydrogen. There is considerable scatter in the data for the analogous system propane-propylene-hydrogen but for most conditions a significant deviation from equilibrium exists. Sulfur compounds in the light oil were of thiophenic character. Ratio of 2- to 3-methylthiophene in the toluene fractions was examined.

Ore Reduction

α-Ferric Oxide: Low Temperature Heat Capacity and Thermodynamic Functions. F. Grønvold and E. F. Westrum, Jr. *J Am. Chem. Soc. 81,* 1780 (1959) Apr. 20 (4 pp.)

Heat capacity of synthetic α-Fe_2O_3 was determined from 5-350° K. No heat capacity anomaly was observed at the magnetic transition about 250°K. Thermodynamic functions have been calculated and the values of Cp, $S°$, $H° - H°_o$, *and* $-(F° - H°_o)/T$ at 298.15° K are: 24.80 cal deg^{-1} mole $^{-1}$, 20.889 cal deg^{-1} $mole^{-1}$, 3718.9 cal $mole^{-1}$ and 8.416 cal deg^{-1} $mole^{-1}$, respectively.

Petrochemicals

Modern Production and Conversion of Chemicals from Petrochemical Materials. E. Kotter. **Part 1. The Paraffin Hydrocarbons.** *Erdöl u. Kohle 12,* 17 (1959) Jan. (4 pp. German text.); **Part 2. Mono-Olefins.** *Ibid.,* 92 (1959) Feb. (9 pp. German text.)

Part 1 presents statistics on American production of petrochemicals as compared with total chemical production. Paraffin hydrocarbons are produced, in greater part, from the lower members of the paraffin series based upon oxidation and chlorination of butane, propane and methane. Sources, production and properties of olefins are discussed in Part 2, with special emphasis on chemical conversion processes used in hydrolysis, chlorination, oxidation, oxoreactions and polymerization for commercial products.

New Petrochemical Process Upgrades Refinery Tail Gases. C. G. Gerald, G. L. Hervert and C. B. Linn. *Petrol. Eng. 31,* C-6 (1959) Apr. (4 pp.)

New petrochemical process for economical manufacture of alkylated aromatics of particularly high purity offers refiners an opportunity to diversify and to make products which are in wide demand in the petrochemical industry. Such diversification of refinery products, apart from the demand for fuels, will stabilize refinery profitability. Principal products are ethylbenzene and cumene. Developed by Universal Oil Products Company, the new process, named Alkar, uses an entirely new fixed bed catalyst system, which is discussed.

Recent Developments in the Oxo Process. P. W. Sherwood. *Petrol. 22,* 169 (1959) May (4 pp.)

Oxo reaction for the production of straight-chain aldehydes and alcohols is one of the few wholly novel methods of synthesis which was adopted directly in the petrochemical field. The method, which effects the reaction of olefins with carbon monoxide and hydrogen, was originally developed in Germany, and a commercial Oxo unit was taken on stream by Ruhrchemie A.G. during the early 1940's.

Petroleum Gasification

Utilisation of Residual Fuel Oil. Part 1. Some Effective New Processes. P. W. Sherwood. *Petrol. 22,* 7 (1959) Jan. (4 pp.); **Part 2. Catalytic Cracking and Hydrogenative Upgrading.** *Ibid.,* 61 (1959) Feb. (5 pp.); **Part 3. Hydrogenative Upgrading and Conversion to Fuel Gas and Petrochemicals.** *Ibid.,* 132 (1959) Apr. (4 pp.)

Series discusses operating techniques which will minimize the formation of residual oils and favor production of the more marketable distillate fuels, a problem which is perhaps more acute in the U.S. than in Great Britain. Part 1 deals with coking methods, upgrading by solvent treating methods and precipitation of asphaltenes by polymerization. Catalytic cracking processes and hydrogenative upgrading of residua are subjects of Part 2. It is pointed out that use of hydrogenation conditions makes it feasible to crack a given petroleum stock at relatively low temperature, thereby supressing C formation. Also H:C ratio of heavy products may be held high enough to render the high-boiling fraction a suitable stock for further cracking. Together, these two factors have the effect of leading to much higher gasoline yield and lower coke and gas formation if cracking is carried out under hydrogenative conditions. Part 3 gives further details of hydrogenative upgrading of residua, including destructive hydrogenation. Finally, a brief outline of the conversion of residua to reformed gas and petrochemical intermediates is given.

Petroleum Refining

Skelly's New HF Alky Unit Points Some Trends. D. E. Phelps and J. C. Reidel. *Oil Gas J. 57,* 82 (1959) May 4 (4 pp.)

Water shortage problem in the El Dorado, Kans., area prompted Skelly Oil Co. to incorporate aerial cooling on a large scale in the design of its new 3500 bbl/d HF alkylation unit. All condensers, except the relatively small acid-rerun condenser, are air-cooled. A total of 70 MM Btu/hr is handled by aerial cooling. Extensive use of this type of cooling led to a major change in the conventional fractionation scheme. The depropanizer is placed ahead of the deisobutanizer. This has a threefold advantage: (1) The deisobutanizer can be operated at lower temperature and pressure to minimize possible corrosion in the large deisobutanizer; (2) all but a trace of the HF is removed ahead of the deisobutanizer, and (3) a utility savings results since the propane in the reactor effluent need be vaporized and condensed only once.

Propane

At Fort Benning, Georgia . . . New Propane-Air Peak-Shaving Plant 'Completely Different' Mixing System. *Am. Gas J. 186,* 45 (1959) May (2 pp.)

Outstanding feature of new peak shaving plant is that it gives a predetermined Btu gas content almost immediately upon startup and maintains this Btu content throughout the full operating range of the plant—even when instantaneous load changes might occur at a very frequent rate. In fact, basic principle of uniquely designed mixing system guarantees no appreciable Btu fluctuations on startup or on load changes. Plant facilities consist of a tank car unloading station, seven 30,000-gal propane storage tanks, a propane liquid booster pump, a mixer house divided into two rooms—one housing the vaporizer and mixer and the other housing the boiler, air compressor and control panel. Propane-air plant is put on the line to supplement natural gas supply and to keep system pressure at its standard 30 psi.

Reformed Gas

Gas Produced in Platinum Catalyst Reforming. W. L. Nelson. *Oil Gas J. 57,* 123 (1959) Apr. 20.

Amount of methane, ethane and propane that will be produced can be predicted with good accuracy by using table shown, but the amount of hydrogen produced is only most approximate. Hydrogen lines are accurate to only about ±20%. Inaccuracy may be due to many variables which have not been completely explored, but a main reason for the inaccuracy is probably the mechanical difficulties encountered in measuring the weight of hydrogen.

Synthesis Gas

Production of CO and H_2 from Natural Gas by Oxidation Conversion under Pressure. A. A. Anisonyah et al. *Gasovaya Prom.* 34 (1959) No. 3 (6 pp. Russian text.)

Pilot plant operation described for production of synthesis gas by partial combustion of natural gas and oxygen under 10 atms pressure. Fed gas with O_2/CH_4 ratio of 0.77 produces 1.4 volumes of product gas with a composition of 3.6% CO_2, 34.6% H_2, 0.3% CH_4, 59.2% H_2 and 2.3% N_2. A small amount of carbon is formed.

J. W. Penney

Tar

Tar, Obtained by the Gasification of Brown Coal from the Ishra-Borodin Mines, as a Raw Material for the Chemical Industry. L. S. Makuvetskit and G. B. Kigel. *Gazovaya Prom.* 16 (1959) No. 4 (4 pp. Russian text.)

Tar produced by gasification of brown coal from the Irsha-Borodin Mines, under pressure with a steam-oxygen blast, is a valuable raw material for the chemical industry. The tar contains 15.7% phenols, 3.5 pyridine bases and 33% hydrocarbons. The hydrocarbons analyze 24% (86-290° C) and 52% (290-345° C). Plastics and surface agents are possible products.

J. W. Penney

Carbon Monoxide

Process for the Production of Carbon Monoxide from a Solid Fuel. H. V. Atwell (assigned to The Texas Company.) U.S. 2,879,148 (1959) Mar. 24.

Solid carbonaceous fuels below 74 microns are gasified with oxygen in a flow-type (suspension) generator at over 2000° F and over 100 psig. The hot gases are reacted further in a second zone with coarser coal particles (above 74 microns) and steam at a temperature above 2000° F to reduce the CO_2 to CO. The second zone may be a dense fluidized bed.

Coal Gasification

Production of Fuel Gases from Granular to Pulverulent Fuels. W. Alstaedt, E. Bartholome and E. Lehrer (assigned to Badische Anilin- & Soda-Fabrik AG.) U.S. 2,878,110 (1959) Mar. 17.

In the gasification of granular fuels, an improved process is claimed for a two-chamber apparatus, the first a cylindrical vessel narrowing to a funnel-section at the base, steam, air and coal feed at the top, the air (enriched) fed at a central pipe to produce downward directed flow with about 20% of required air, and the second vessel a cylindrical main gasifying chamber fed tangentially by the coal and air from

the bottom of the first vessel, where the remainder of air is introduced through target jets.

Hydrogen

Method of Making Hydrogen and Apparatus Therefor. A. M. Thomsen. U.S. 2,879,139 (1959) Mar. 24.

Improved method of hydrogen manufacture is claimed which includes passing by a blower a fluid consisting of hydrogen, nitrogen, steam and air alternately in opposite directions through a body of carbon (charcoal) at 1200° F, and removing the heat in an accumulator and then extracting the CO_2 by means of an alkali scrubber.

Ore Reduction

Method of Producing Sponge Iron. F. O. Wienert (assigned to R-N Corporation.) U.S. 2,880,083 (1959) Mar. 31.

Improved iron ore reduction is obtained, without sulfur contamination, by first coating the moistened solid fuel (3 mm coal or char) with calcium or magnesium oxides or hydroxides (minus 20-mesh) and passing this coated fuel with the iron ore into a rotary kiln reducing stage. Sponge iron is recovered from kiln product by magnetic separation, and char, recovered by screening out sulfided lime over a 20-mesh screen, is recycled to process.

Method for Reducing Metal Ores. R. P. Smith and D. E. Babcock (assigned to R-N Corporation.) U.S. 2,877,108 (1959) Mar. 10.

Improved process of iron ore reduction provides a primary rotary kiln fed by lump (to 1½ in. diam.) iron ore and devolatilized char (3 mm) in ratio of 100:65 with outlet zone heated by oil burner to 1900° F. Hot discharged product is fed directly to the secondary kiln, there mixed with non-coking coal, with the heat of ore used to devolatilize the coal, with volatiles collected and fed to the burner on the primary kiln. Product of the secondary kiln is screened and magnetically separated to remove reduced ore, and the remaining char is returned to the primary kiln.

Method for the Reduction of Oxides. O. E. A. Aspegren (assigned to The Oil Shale Corp.) U.S. 2,877,106 (1959) Mar. 10.

Process for ore reduction is claimed in which heat-donor bodies such as iron balls are passed with hydrogen gas in counterflow to iron ore. Process occurs in three zones: Ore preheating, reduction and ball preheating, with auxiliary preheating devices for the balls and the hydrogen.

Smelting Finely Divided Iron Ore. W. E. Greenawalt. U.S. 2,876,092 (1959) Mar. 3; **Processes of Smelting Finely Divided Iron Ore.** W. E. Greenawalt. U.S. 2,876,093 (1959) Mar. 3.

These patents show an improved method of smelting finely divided iron oxide ores which includes first showering the ore through a highly heated shaft melting furnace with the upper zone maintained in an oxidizing state and the lower zone in a reducing state. The resulting partly reduced ore then is passed down though another shaft furnace filled with hot coke to complete the reduction to pig iron and slag. The top gases of the coke-filled shaft are passed upward through the upper "melting furnace" shaft.

Shale Oil

Shale Oil Recovery Method and Apparatus. D. B. Brice (assigned to The Fluor Corp., Ltd.) U.S. 2,879,208 (1959) Mar. 24.

Improved operation and yields of shale oil are obtained in a shaft retorting process by raising or lowering gas flow between intermediate vertical zones to restrict or permit gravitational flow of shale between zones.

8. GAS DISTRIBUTION

Distribution Systems

A Valve Maintenance Program for Gas Distribution Systems. C. R. Newlin. *Am. Gas J. 186,* 47 (1959) May (3 pp.)

Planned, preventive maintenance on distribution system valves is good insurance that . . . when and if the valve is needed . . . it will work. Experiences at New Orleans Public Service . . . and suggestions on how to develop programmed lubrication procedure.

Leakage

Locating Leaks on New Main Construction. J. G. Sweeney. *Gas 35,* 75 (1959) Apr. (3 pp.)

Brooklyn Union Gas Co. has adopted this method for locating leaks on new main construction: Air which is being pumped into the section of main to be tested is supplied with trichlorethylene vapor so that the resulting compressed air has at least a halide concentration of 1000 ppm. Barholes are made at all joints and fittings in the main. A ⅜-in. copper probe, the length of which depends on the depth of the barhole, is connected with a short piece of rubber tubing to the charcoal tube, which is, in turn, connected to an aspirator bulb. Atmosphere in the barhole is aspirated through the charcoal by squeezing the 100-cc aspirator bulb at least 25-30 times. Contents of each carbon tube used is dumped separately into the red hot copper screen basket

and if halide is present, the characteristic green color will be imparted to the flame of the halide detector burner. With use of these carbon tubes and the heating on the halide burner, 25 ppm of halide can easily be detected in air.

New Gage Invented by Gas Service Men Permits Faster, More Accurate Testing. *Gas Age 123,* 42 (1959) Apr. 2.

New gas pressure gage, said to show up a leak in a gas pipeline installation or meter-to street line in less than two minutes, is now being used in northern Ohio. The instrument, called the D100A Pneumatometer, and invented by two employees of the Ohio Fuel Gas Co., measures either pressure or vacuum, and reads out directly in inches of water, or pounds and ounces.

The Philadelphia Story. Internal Sealing Proves Itself as Effective Control Method. J. L. Peters. *Am. Gas J. 186,* 39 (1959) May (5 pp.)

Results of a survey indicated that approximately one mile of the Philadelphia Electric Company's 5 psig, 8-in. main was leaking to such an extent that immediate corrective measures were necessary. Although the clamps had been installed some 30 years earlier, it was particularly discouraging to find that leakage was found where the main had been clamped. To arrive at a solution to correct the leakage, four methods were considered: Wetting agents to revive the jute, leak clamps, new main and internal sealing. Article discusses why latter method was chosen, how problem was corrected and effectiveness of the method.

Metering

Effect of Rate of Flow on Meter Proof. R. L. Jones and C. J. Sevey, *Gas Age 123,* 31 (1959) Apr. 30 (3 pp.)

Test results which may aid in setting rates of flow to meet individual meter proving problems are presented. It is indicated from these data that meter accuracy curves probably follow the straight line theory; meter's entire range cannot be determined accurately without knowledge of the proof curve; the higher the rate, the faster a meter can be tested.

Recent Trends in Meter Maintenance Practices—A 15-Company Survey. F. J. Frederick. *Gas Age 123,* 32 (1959) Apr. 16 (4 pp.)

While trend is toward less work on meters through the aid of increasing automation, gas companies in general are building new shops, investigating automatic proving circuits, searching for improved equipment and employing more mechanical devices for processing and handling meters. Quality control studies also are under way in many cases.

Sizing of Domestic Types of Meters to Known Gas Loads at Low Pressure. T. F. Larche. *Gas Age 123,* 27 (1959) Apr. 30 (4 pp.)

Mississippi Valley Gas Company uses a "three-dimensional" method of sizing meters to gas loads based on hourly demand, maximum month and 12-month sendout figures. If any of these three figures exceed those compiled on the company's standard meter and regulator sizing chart by 10% or more, a larger meter is used. Sample of chart is included as well as detailed description of the method.

Want to Move Those Meters Outoors? Temperature Compensating Meters May Be the Answer. J. F. Ebdon. *Gas 35,* 61 (1959) May (7 pp.)

Reasons for interest in metering outdoors rather than indoors are many: Better customer relations, reduction in service line costs to gas companies, meter changes can be accomplished without gaining entry to homes, permits easy turn-offs for nonpayment, lower meter reading costs, eliminates estimated bills and resulting factors, no delayed revenues due to "no-reads" which cannot be estimated, Area turn-offs can be made more quickly and surely, with fewer people, during an emergency, significant decrease in probabilities of shorts in cathodically protected systems, and prefabrication of meter and regulator assemblies is permitted. Article describes Northern Illinois Gas Co.'s research into development of temperature compensating meters. Among the considerations: Fact that metering temperature and the ambient temperature are, for practical purposes, identical. Another problem for exploration was the theoretical metering error plotted with progressively lowered temperatures. Company developed a cold box in their testing laboratory. Field tests indicate that the industry has a temperature compensating meter that promises to solve the problems for those gas companies that currently meter indoors because of widely varying atmospheric temperatures.

Piping

PIPE: Lifeline of the Gas Industry. C. A. Gallagher. *Gas Age 123,* 38 (1959) Apr. 2 (3 pp.)

Industry is offering the distribution or planning engineer a widening choice of pipe materials to assist in meeting the distribution problems involved in a growing and broadening demand for natural gas. While some must still pass the test of time under operating conditions, the gas utility need not fear "hardening of the arteries." Article presents comparison of costs in per cent for ductile or nodular iron mechanical joint pipe, mill wrapped steel pipe (both

expressed in the cost of class 150 mechanical joint gray cast-iron pipe) and mill wrapped steel pipe in per cent of the cost of ductile or nodular iron.

Plastic Pipe Storage, Handling and Use. H. E. Wade. *Am. Gas J. 186,* 60 (1959) May (2 pp.)

As new types of material become available for use in gas distribution industry, it is necessary to develop economical and proper methods for handling, storing, control and issuance of such items. Experiences of The Peoples Gas Light and Coke Company are subject of article.

Wrought Iron, Wrought Steel Piping Standard Is 20 Years Old this Month. H. H. George. *Heating, Piping & Air Conditioning 31,* 110 (1959) Apr. (4 pp.)

ASA B36.10 has been indispensable to consulting engineers and piping contractors for a score of years. Too few people are familiar with the derivation of the schedule number system or with the differences between the dimensions for schedule wall pipe and those for the more traditional weights: "standard," "extra strong," and "double extra strong." Short review of B36.10 is presented which includes some of historical highlights that led up to its being established, as well as data on current pipe sizes and wall thicknesses as they are defined by the Standard.

Weather Forecasting

Load Calculations Using Pretabulated Admittance Functions. W. B. Drake. *ASHRAE J. 1,* 71 (1959) Apr. (4 pp.)

As a simple and accurate method of load calculation, this procedure requires no special computing machines. It does make use of information obtained previously with computing machines and is sufficiently flexible to allow the utilization of local time variable weather data. Results of calculations are compared with those based on equivalent temperature differentials given in the ASHAE Guide of 1957.

Making Weather Less Mysterious. *Business Week 1549,* 123 (1959) May 9 (2 pp.)

Along the East Coast, a chain of weather stations planned for the Air Force will utilize a method of long-range forecasting which will apply a theoretical approach. It involves constantly observing every aspect of weather by every possible means. Basic premise of this system is that one must know everything about the weather before one can know anything—that in predicting temperatures, for example, it is insufficient just to study past temperatures. To find out everything about the weather, it is necessary to utilize all sorts of modern devices. Resulting data, fed into a computer, should yield a picture of what can be expected weatherwise.

9. GAS FUEL UTILIZATION AND APPLIANCES

Air Conditioning

Solar Space Cooling. R. Chung, G. O. G. Lof and J. A. Duffie. *Chem. Eng. Progress 55,* 74 (1959) Apr. (4 pp.)

Design considerations and test results to provide a nominal cooling capacity during a normal eight-hour working day using energy supplied by a solar source. Under conditions assumed in study, an overall COP of about ¼ is indicated (four Btu radiation incident on the collector will produce about one Btu of cooling, under good radiation conditions.) Thus the collector area requirements indicated by this study are about 160 sq ft/nominal ton of cooling capacity for an eight-hour day (or 480 sq ft/ton-day of cooling) for a well designed collector with optimum orientation, a cooler with high coefficient of performance and typical clear day radiation.

Air Pollution

Catalytic Air Treatment as a Production Tool. P. H. Goodell. *Air Eng. 1,* 52 (1959) Apr. (5 pp.)

Important consideration in air engineering is ability to decontaminate, reclaim and re-use process air for heating, cooling and other processes. Following nature's process of purifying by oxidation, air technology now includes means for rapid, complete and reliable oxidation of all organic and combustible type contaminants regardless of dilution, or their ability or inability to support flame propagation. This means, known as catalytic oxidation, simply requires momentary contact of the gases with a catalytic material at suitable temperatures.

CO-Boiler Protects California Air. *Petrol. Week 8,* 39 (1959) May 8.

Waste gas boilers, using as fuel the carbon monoxide and unburned hydrocarbons coming from the regenerator of a catalytic cracking unit, are a "must" in any area where air pollution is a critical problem, according to refiners in the smog area on the West Coast. Regenerator gas, which contains about 5% by volume of CO, has an approximate heat value of 15 Btu/CF. It leaves the regenerator at a temperature of 1070°-1100°F. Gas is burned in the primary combustion chamber in conjunction with auxiliary natural gas, and 10-20% excess air under pressure at a temperature of about 1800°F. Flue gases are used to preheat the feedwater in an econ-

omizer and are then discharged at 525°F. Boiler produces 300,000 lb/hr of saturated steam at 710 psi. Steam is superheated in superheater buried in the regenerator fluidized catalyst bed. Final steam production is 400,000 lb/hr.

Gas-Fired Incinerator Stops Air Pollution at Salvage Plant. R. W. Lockwood. *Ind. Gas* (U.S.) *37,* 3 (1959) Mar. (2 pp.)

Non-ferrous scrap dealers engaged Thermo-Metal, Inc., of South Orange, N. J., to help solve smoke and air pollution problem. Thermo-Metal, after careful analysis of problem and methods of operation, designed a batch-type incinerator. Gas-fired unit is capable of 750-1000 lb of wire/chamber (there are two) and requires a burning time of between 30-40 minutes/batch.

Clothes Dryers

Automatic Clothes Dryers—Their Performance and Effect on Certain Fabric Properties. E. S. Ross, K. Taube, N. Poole and L. S. Thye. (Washington, D. C.: U. S. Dept. of Agriculture, Home Economics Research Rep. No. 6.) 1958 (Oct.)

Effects of repeated drying of fabrics in automatic gas and electric dryers, on racks indoors, and on lines outside, protected and unprotected from the sun, were investigated. To obtain quantitative data, experiments were designed to measure changes from the original in color, chemical properties, strength and dimensions in the fabrics dried in various ways. In addition, the effect of certain factors (composition, and moisture content of the load and special design features of the dryers) on the efficient use of dryers also was investigated. Operating and performance characteristics of dryers also were studied.

Flame Research

Carbon Formation in an Acetylene-Air Diffusion Flame. M. E. Milberg. *J. Phys. Chem. 31,* 578 (1959) Apr. (5 pp.)

Rate of soot issue from an acetylene-air diffusion flame has been measured as a function of pressure and air/fuel ratio. Soot has been analyzed for soluble and volatile constituents by infrared and ultraviolet absorption spectroscopy and mass spectrometry. Rate measurements can be explained on the basis of a soot formation rate which varies linearly with pressure and is independent of air/fuel ratio. Analyses showed the presence of polynuclear aromatics and oxygenated aliphatics. Rate and analytical results are consistent with a pyrolysis mechanism of carbon formation involving polymerization of acetylene to large aromatic molecules followed by carbonization. Oxygen may be involved in the pyrolysis process.

Chemistry of Very Rich Fuel-Air Flames. J. Grumer and J. M. Singer. (Pittsburgh: Bureau of Mines, Progress Report 10, Oct. 1-Dec. 31, 1958; A.G.A. Project ZC-20.)

Experiments at Bureau of Mines laboratories suggest that the carbon-forming mechanism in carbon-forming rich flat flames of propane involves two stages: 1) Nucleation stage marked by pyrolysis of low molecular weight hydrocarbons surviving the first blue flame, and 2) growth stage of carbon particles in the yellow luminous flame, characterized by a continuously changing physical form of the carbon (when examined under the electron microscope), and a negative temperature gradient. In contrast to smoking premixed flat flames where very little reaction occurs before the first luminous blue flame, smoking conical diffusion flames contain smoke and gaseous combustion products in the flow far upstream of the first zone of luminous flame.

Ignition in the Shock Tube. E. Schmidt. *Brennstoff-Wärme-Kraft 10,* 295 (1958) June (4 pp. German text.) (From *Appl. Mech. Rev. 12,* 280 (1959) Apr.)

Compression in a shock front presents an ideal means for raising the pressure and temperature of the gas to a desired enhanced value, and for observing whether reaction ensues, with or without time delays. Though observation of them is convenient, stationary compression shock fronts require very considerable quantities of gases. Short-lived compression shocks can however be studied in shock tubes. Diagrams and photographs are given of a shock tube 4-mm long and 21 by 30-mm internal cross section, constructed by the authors. Schlieren photography is recorded of ignitions in reactive mixtures such as $2H_2 + O_2$. Illustrations are given of delays to ignition, of pre-ignition reactions and of detonations. Spinning wave fronts are recorded. In Germany it is planned to extend this work to include photography with 25,000 frames/sec.

A. R. Ubbelohde, England

Model Investigations int the Factors Affecting the Mixing of Gas and Air in Coke Oven Flues. V. Jayaraman, C. Hulse and M. W. Thring. *Combustion and Flame 3,* 97 (1959) Mar. (6 pp.)

Length of the heating flame in a coke oven flue is governed only by the mixing of the gas and the air, but the factors that govern such mixing are not clear. This model work is an attempt to establish these for the case of rich (coke oven) gas firing. It has been determined that a wide range of flame lengths can be obtained for the same flow rates by employing burners and air ports of different cross-sectional area. A scale theory is put forward to render the model results applicable to actual systems. Theory

has been roughly confirmed for a particular case, by carrying out full-scale trials in an operating coke oven flue. Work on further confirmation is progressing at the University of Sheffield, England.

Optical Refractivity of High-Temperature Gases. I. Effects Resulting from Dissociation of Diatomic Gases. R. A. Alpher and D. R. White. *Phys. Fluids 2,* 153 (1959) Mar.-Apr. (9 pp.)

Shock tube and discharge techniques make it possible to generate in the laboratory significant volumes of dissociated and/or ionized gases. Article describes some studies of the optical index of refraction of dissociated diatomic gases. Physical interpretation of specific refractivity is discussed and related to polarizability, and various methods of computing such quantities are reviewed briefly. Shock tube experiments are described in which optical interferometry has been utilized to measure the polarizability of atomic oxygen and nitrogen. Use of optical interferometry for determination of gas density has been justified for experiments involving air at temperatures to at least 5000° K.

Optical Refractivity of High-Temperature Gases. II. Effects Resulting from Ionization of Monatomic Gases. R. A. Alpher and D. R. White. *Phys. Fluids 2,* 162 (1959) Mar.-Apr. (8 pp.)

Articles describes shock tube studies of the optical index of refraction of ionized argon in which observed optical effects have been related to the ionization of the shocked argon. Plasma dispersion formula has been applied to the measured refractivities to determine values of equilibrium electron concentrations on the order of $10^{17}cm^{-3}$. Good agreement is found between experimental and calculated values of the degree of ionization. Ionization relaxation process is strikingly portrayed in the interferograms and may be studied in some detail. Some questions concerning proposed kinetics for the relaxation behind strong shock waves in monatomic gases are discussed.

The Source of the Continuum in Carbon Monoxide-Hydrogen-Air Flames. W. E. Kaskan. *Combustion and Flame 3,* 39 (1959) Mar. (10 pp.)

Source of the continuum from flames containing carbon monoxide and oxygen has been investigated by measuring both the emission intensity and OH in the flame gases from rich carbon monoxide-hydrogen-air flames. Concentrations of carbon monoxide are calculated from the water gas equilibrium and those of oxygen atoms are calculated from the measured OH. It is shown that the light-producing step involves a reaction between a carbon monoxide molecule and an oxygen atom with a rate constant of 2.7×10^{-19} cm^3/molecule sec. In the range of conditions employed the continuum amounts to about 95% of the radiation. It is shown that the rate of decay of radicals is not much affected by the presence of carbon monoxide and carbon dioxide.

Theory of Flame Propagation. Y. B. Zeldovich and G. I. Barenblatt. *Combustion and Flame 3,* 61 (1959) Mar. (14 pp.)

Previous work on steady state propagation of flat flames is reviewed and various mathematical techniques are contrasted. In the numerical evaluation of the velocity of uniform propagation of flames, the effects of varying parameters, heat loss and chain reactions are considered, leading to analysis of stability of propagation. Limits of validity are presented.

Transition Probability Parameters of Molecular Spectra Arising from Combustion Processes. R. W. Nicholls, P. A. Fraser and W. R. Jarmain. *Combustion and Flame 3,* 13 (1959) Mar. (26 pp.)

Dependence of intensity distribution in molecular spectra upon 1) source conditions and 2) molecular constants (particularly transition probabilities) is reviewed briefly. Knowledge of transition probabilities is essential to the interpretation of spectral intensities in terms of source conditions. Arrays of Franck-Condon factors, $q_{v'v''}$, which are closely related to relative vibrational transition probabilities, $p_{v'v''}$, have been computed upon a Morse model and are presented for a comprehensive range of band systems of significance in combustion processes for the molecules C_2, CN, B_2, BO, BH, BN, OH, O_2, NO, PbO. Where available, values of smoothed relative vibrational transition probabilities $p_{v'v''}$ and band intensities at infinite temperatures $I_{v'v''}$, also are presented.

Turbulent Flame Studies in a Two-Dimensional Open Burner. J. H. Gover, E. N. Fales and A. C. Scurlock. *ARS J. 29,* 275 (1959) Apr. (9 pp.)

Two-dimensional open burner has been developed for studying turbulent flames. Stoichiometric natural gas-air flames with inlet flow velocities of 15, 20, 30 and 40 ft/sec were investigated. Densitometer traverses of time exposures were used to locate the position of the mean flame front and its root-mean-square displacement. Flash tube exposures of the flame with one-micron magnesium oxide particles in the flow were taken to determine the flow lines into and through the flame front. Large reduction of brightness that occurred when the flow passed through the flame front, because of the reduction of particle concentration, shows clearly the outline of the instantaneously wrinkled flame front and the islands of unburned gas often present in the burned gas. From the intercepts of the flow lines and the

mean flame front, the local turbulent flame velocity along the flame front was calculated. Turbulent flame velocity increased rapidly with distance above the burner rim. Flame velocity increase can be entirely accounted for by flame wrinkling. Both this result and the appearance of the flash tube photographs, showing the instantaneous flame front, support the wrinkled flame concept of turbulent flame propagation.

Furnaces

Furnace Offers Industry New Heating Device. Dr. DiGiulio. *A.G.A. Monthly 41,* 26 (1959) Apr. (3 pp.)

Bal-Tate Furnace Co., Ferndale, Mich., is manufacturing a new type of furnace which produces many tons of extruded shapes, and which can be used in operations such as forging, hot forming, and high temperature thermal treating of special metals and alloys. Furnace, which was originally built in Milan, Italy, offers a heating device heretofore unavailable to American industries. In the Bal-Tate furnace, glass performs the following functions: "Pickles" the billets, produces a hot scale-free surface, eliminates the direct impingement of the flame on the steel surface, effectively adheres to the refractory lining of the furnace, makes a glass layer on the billets and on the surface of the furnace and makes a protecting layer on the metal surface.

Heat Pump

Heat Pump Performance for Packaged Air Source Units. W. A. Spofford. *ASHRAE J. 1,* 59 (1959) Apr. (5 pp.)

Air source heat pumps serve the dual purpose of cooling in summer and heating in winter. Advantages of heating with the heat pump depend to a great extent on its ability to add heating to its cooling function with a minimum of additional equipment and services. Modifications to add heating function to electrically operated mechanical refrigeration cooling equipment consist of a switchover valve to reverse the flow of refrigerant, automatic defrost means and other suitable controls for year-round operations. Performance of this type of equipment is discussed in terms of the variables that affect its performance. Since this performance changes with the weather, it is necessary also to consider the average performance for the season, as well as the extent and duration of the extremes.

Industrial Heating

Advantages of Rapid Heating of Steel for Forging. A. M. Thurston. *Ind. Gas* (U.S.) *37,* 13 (1959) Mar. (3 pp.)

Fundamental purpose of heating for forging, is to heat metal to such a state of plasticity that it flows easily, quickly and uniformily into die recesses. For this prime purpose slow heating is now seen to offer an inherent impediment. Metals employed for forging have shown different flow characteristics when heated slowly than when heated rapidly. With conditions constant as to grade and peak temperature, fast-heated metal flows more readily than when heated slowly. Short heating cycles reduce scale and grain growth, and promote plasticity and better die life.

How the Gas Industry Serves a Mainly Agricultural Area. R. F. Saggers. *Ind. Gas (Brit.) 22,* 19 (1959) Apr. (7 pp.)

Author discusses how and why one firm in East Anglia (England), famous for its agricultural machinery, utilizes approximately 800,000 therms of town gas per annum. Facilities, equipment and interesting applications are included.

LPG

Steam Evaporators and Superheaters for Propane and Butane. A. K. Troshin. *Gasovaya Prom. 15* (1959) No. 3 (9 pp. Russian text.)

General description and detailed design calculations for coefficients of heat transfer, heating surface. Seven design examples are presented.

J. W. Penney

Propane

Phillips Metal-Cutting Tests Show . . . Propane Is a Better Fuel than Acetylene. *LP-Gas 29,* 43 (1959) Apr. (6 pp.)

While acetylene produces a higher flame temperature, this temperature causes excessive melting and consequently rough metal edges. With an oxy-propane tip, the operator can minimize edge melting prevalent in the oxy-acetylene method. As a result, cuts are smoother; slag is reduced and more easily cleaned from the metal. Oxy-propane torch tip affords gentle preheating, thereby minimizing the ill effects of extreme temperature.

Space Heating

Infra-Red Space Heating. M. Resek and F. J. Prince. *Air Conditioning, Heating and Ventilating 56,* 74 (1959) Apr. (4 pp.)

Gas-fired radiant heaters are relatively new in the U. S. Article describes ceramic radiant plate, developed by a German scientist, Guenther Schwank, which is heated to 1650° F by a flame on its surface. Catalytic action of the hot ceramic surface on the gas-air mixture results in exceedingly rapid combustion. Plate is incorporated into a burner in which

all air required for combustion is inspirated at the gas orifice. Gas-air mixture burns as it issues through a large number of small holes in the ceramic plate covering the face of the burner. Ceramic plate, ⅜-in. thick, is made of material of extremely low thermal conductivity. Its surface is pierced with a large number of small diameter holes, which serve as gas ports. Large total area of the gas ports result in low back pressure in the burner. This makes it possible to induce all air required for combustion as primary air.

Ventilation

Commercial Kitchen Ventilation and the Effect of Cooking Appliances on Air Conditioning Design. E. A. Jahn. *Air Conditioning, Heating and Ventilating 56,* 89 (1959) Apr. (8 pp.)

Basic factors are covered that determine the required capacity for fans installed as part of a kitchen exhaust system. Information is given on how gas or electric cooking appliances affect the ventilation and air conditioning requirements of the kitchen and dining areas. Extensive table is included which gives the maximum heat gain from appliances located in an air conditioned area.

Burners

Gas Burner and Lighter. F. J. Kindl (assigned to The W. J. Schoenberger Co.) U.S. 2,878,863 (1959) Mar. 24.

Dual burner having a central simmer burner is claimed, which includes radially arranged ignition orifices fed from the central mixing space and ignited by an adjacent fixed pilot flame.

Sonic Velocity Submerged Combustion Burner. J. B. Fenn (assigned to Experiment, Inc.) U.S. 2,878,644 (1959) Mar. 24.

Choked fuel burner is operated at sonic velocity of exhaust gases to provide smoother combustion and improved gas-to-liquid heat transfer. Heat-transfer liquid is of low vapor pressure, high-boiling type (such as silicones, phthalates, molten salts or metals) which transfers heat to submerged water coils or water tubes for steam generation.

Ignition

Ignition Devices for Gas Burners. B. L. Matthews and E. J. Zarybnicky (assigned to The W. J. Schoenberger Co.) U.S. 2,878,862 (1959) Mar. 24.

Ignition device for gas burners is claimed which comprises an individual pilot port in the rear side wall of the burner chamber, a tube-fed pilot flame spaced to fire into port and fed from the stove manifold, and a draft-shield protecting said pilot flame.

10. EQUIPMENT AND INSTRUMENTATION

Computers

How Digital Computer Solves Gas Engineering Problems. H. J. McCain, Jr. *Gas 35,* 65 (1959) Apr. (3 pp.)

In addition to apparent advantages of accuracy and speed, there are other advantages due to the speed of the computer. For example, a sufficient number of trials may be conducted to obtain the best solution for improving existing distribution facilities to adequately meet expected future loads. Although the only problems now being solved on the computer are the distribution and traverse problems, others are being considered. Among these are high pressure gas transmission, mechanical design of pipelines and compressor stations, and gas reservoir calculations for storage and production wells. It is difficult to assess a fixed dollars value on the computer to the company. Its use has saved time in the operation of the engineering department by eliminating the needless mapping of inaccurate surveys and by increasing the speed of mapping through the use of coordinates rather than distances annd angles. It has accelerated the work of the planning department by providing a means of obtaining fast and accurate answers to distribution network problems.

Journal Survey Shows Extent of Oil Industry's Use of Electronic Digital Computers. G. L. Farrar. *Oil Gas J. 57,* 116 (1959) Apr. 13 (6 pp.)

Five-page table indicates that 167 high-speed, high-capacity electronic digital computers and data-processing machines are installed or on order by oil companies in the U.S. and Canada and by U.S. oil companies and affiliates worldwide. Figure does not include installations of contractors, engineering service companies, computer service companies, or of chemical companies with petrochemical operations; it includes only the facilities of oil companies as such.

A Method of Successive Approximations for Computing Combustion Equilibria on a High Speed Digital Computer. D. S. Villars. *J. Phys. Chem. 63,* 521 (1959) Apr. (5 pp.)

Procedure has been developed for rapidly solving complicated thermodynamic equilibria by a flexible iteration method which can be readily extended to include additional chemical elements. Changes in composition are computed for only one reaction at a time, neglecting the interaction of such changes in composition on the other equilibria. Current values of concentrations are used to calculate back all equilibrium constants. For the next computation,

the program selects that reaction showing the greatest discrepancy between calculated and given equilibrium constant. Discrepancies are then recalculated and another determination made of the reaction showing the greatest discrepancy. Process is repeated until the maximum discrepancy is reduced to a value less than an error, E, specified as a parameter of the problem. Speed of convergence may be maximized by expressing all species in terms of components existing in the largest concentrations at equilibrium. A subiteration procedure is utilized for solving the individual equations.

Stripper-Stabilizer Problems Yield to Digital Computers. C. R. McNeese. *Oil Gas J. 57,* 106 (1959) Apr. 27 (6 pp.)

Atlantic Refining Co. has developed a program to give fast, accurate solutions to multicomponent fractionation problems. Program was evolved specifically for design and development work on cold-feed stabilizers (i.e., stripping operation). But this approach has other applications; for example, 1) problems involving rectification as well as stripping, and 2) R.O. deethanizer, which involves absorption and stripping. Program is based on the Edmister stripping-factor method. A "theta" method, used in a manner quite similar to that of Lyster, Sullivan et al. is employed to force rapid convergence.

Technical Computer Applications for the Small Refiner. W. S. Pickrell. *Petrol. Eng. 31,* C-39 (1959) Apr. (3 pp.)

During the past four years, petroleum industry has recognized the digital computer as an extremely valuable tool, to the extent that by January, 1958, 76 medium-size computers and 8 large-scale computers were in use. Application of computers in refineries is well in advance of that in other areas of the oil and gas companies, probably because refinery problems are better defined. Major problems solved on computers by refinery personnel are 1) economic and optimization studies, 2) unit process calculations and 3) process designs. Article discusses some of the more well-known applications in the first category.

This Component Program Handles Wide Composition Range. R. N. Maddox and J. H. Erbar. *Oil Gas J. 157,* 116 (1959) Apr. 27 (4 pp.)

At Oklahoma State University, a plate-to-plate computer program has been developed which 1) is available to the public at large, 2) is designed to IBM 650 but can be adapted for nearly any medium-sized computer, and 3) has proven capable of handling all feed streams thus far attempted. This last includes systems with methane through absorption oil and other systems containing components ranging from hydrogen through 360° F normal boiling point oil.

Engines

Gas Engine Operation As Seen with an Electronic Analyzer. M. G. Wallington. *Gas Age 123,* 38 (1959) Apr. 16 (3 pp.)

Observance of the operation of gas engines using an electronic analyzer. Analyzer described in article is the Industrial Engine Analyzer developed by the Sperry Gyroscope Company.

Gas Turbines

Power-Recovery Gas Turbines for Fluid-Bed Processes. J. C. Dygert. *Oil Gas J. 57,* 94 (1959) Apr. 20 (7 pp.)

If given the right job, the gas turbine reigns supreme; no other system can match the efficiency or low equipment cost. In fact, no other type of prime-mover equipment is mechanically acceptable. Systems referred to are those in which one or more portions of the gas turbine's cycle — compression, combustion, expansion — can become an integral part of a complex process. Prime area for exploitation is the fluid-bed type of process. Examples are fluid catalytic cracking units in oil refineries and the direct reduction of iron ore in fluid beds. In these systems, turbine-blade wear stems from erosion; fine particles escaping from the fluid beds are the culprits.

Studies in the Chemistry of the Operation of Solid-Fuel-Fired Gas Turbines. Part 1. Pulverized Peat as an Open-Cycle Gas-Turbine Fuel. J. A. Waddams and J. C. Wright. *J. Inst. Fuel 32,* 178 (1959) Apr. (19 pp.)

Reasons for investigating pulverized peat as a gas turbine fuel are given together with a consideration of peat as a fuel, its characteristics and those features that are responsible for the problems met when using it in a medium-power open-cycle gas turbine. Three main problems are erosion, corrosion by some constituents of the peat ash and ash deposition on the turbine blade. Literature concerning similar problems allied with the peat-fired gas turbine project, including ash deposition in coal-fired or oil-fired gas turbines and corrosion and as deposition on boiler tubes, is reviewed.

Studies in the Chemistry of the Operation of Solid-Fuel-Fired Gas Turbines. Part 2. An Investigation of Pulverized Peat and Its Combustion in a Rig Simulating Conditions in an Open-Cycle Gas Turbine. J. A. Waddams and J. C. Wright. *J. Inst. Fuel 32,* 182 (1959) Apr. (10 pp.)

Detail characteristics of the pulverized peat used in experimental work concerning the combustion of peat in an open-cycle gas turbine are described. Particular attention is paid to the characteristics of the ashes formed from the peats after combustion. Chemical analysis and X-ray diffraction studies have helped to establish the actual compounds present in the ash and it is possible to predict some of the reactions which occur in the ash during combustion. A combustion rig was used to see whether the reactions noted in the laboratory studies could be confirmed on a larger scale. This rig is described and it is shown that the rig was capable of reproducing full-scale turbine conditions for the aspects of combustion and ashing under investigation. A typical rig operation sequence is described together with the experimental results. From these and similar results it is possible to predict the probable life history of ash components during and after combustion in the full-scale peat-fired open-cycle gas turbine.

Studies in the Chemistry of the Operation of Solid-Fuel-Fired Gas Turbines. Part 3. Effect of Operating Variables on the Rate of Ash Deposition During Short Runs with a Pulverized-Peat Combustion Rig. J. A. Waddams and J. C. Wright. *J. Inst. Fuel 32,* 190 (1959) Apr. (5 pp.)

For experimental purposes, a pulverized-peat combustion rig was used to simulate the combustion and ashing conditions of the full-scale peatfired gas turbine. A series of experimental runs using the combustion rig is described. Rate of ash deposition on two types of fixed target in the gas stream is shown to depend on the geometry of the target, the temperature and velocity of the gas stream and on time. It can be shown that the rate of ash disposition is largely dependent on the ash population of the gas stream in runs of only a few hours' duration. With a constant ash population, the deposition rate increases with increasing gas and target temperatures.

Pumps

Chemical Pumps. A Commentary on Current Progress and Problems. W. F. Riester. *Chem. Process Eng. 40,* 119 (1959) Apr. (5 pp.)

Summary of advances that have been made by pump manufacturers in providing the special features necessary for chemical pumping duties. These features, which apply to all types—centrifugal, reciprocating and rotary—are: Simplicity of design, suitable materials for wetted and other parts, minimum of leakage points (joints or glands), and capability of dealing with vapor and solids inclusions. Article also discusses briefly some notable developments as well as some needs which have not yet been satisfactorily met.

Temperature Measurement

The Calibration of Thermocouples by Freezing-Point Baths and Empirical Equations. R. P. Benedict. *J. Eng. Power 81,* 177 (1959) Apr. (10 pp.)

Calibration system is described which is based on the use of a few precisely determined experimental values obtained from freezing-point baths. Characteristics of the individual thermocouples at intermediate points are obtained by passing empirical equations of prescribed form through the test values. A program is reviewed, by which a high-speed digital computer accomplishes the necessary conversions, curve fittings, comparisons of individual characteristics with arbitrary reference tables, and the printing out of a table of differences. Test results for a series of iron-constantan thermocouples, over the temperature range 32-1225° F, are presented to illustrate use of the system and uncertainties involved. Comparisons are drawn between these results and those obtained by other methods.

The Design of Mercury Thermometers for Calorimetry. J. A. Hall and V. M. Leaver. *J. Sci. Instruments 36,* 183 (1959) Apr. (5 pp.)

Emergent column error and uncertainties caused by irregular movement of the meniscus in an open-scale thermometer are discussed. It is considered preferable to calibrate calorimetric thermometers at total immersion unless the ambient temperature in use is considerably lower than that of the calorimeter. It is shown that irregularity of movement of the meniscus is, to a sufficiently close approximation, proportional to the external pressure coefficient of the thermometer β_e divided by the diameter of the bore d. If these are expressed in deg C X 0.01/cm of mercury and mm respectively, β_e/d should not exceed 15 when a reproducibility of reading of 0.002° C is desired. Further, it is undesirable to use a capillary having a diameter of less than 60 μm. Article includes a chart by means of which the appropriate sizes of bulb and capillary tubing for a thermometer of given dimensions and scale length may be selected.

Low Temperature-EMF Characteristics of Chromel-Alumel Thermocouples. J. F. Carlson. *Ind. Heating 26,* 688 (1959) Apr. (3 pp.)

In view of increasing interest in sub-zero treatment of metals, special tests recently have been conducted to determine the actual low temperature-emf characteristic of present standard grade Chromel-Alumel wires as compared with the values established for these alloys by the National Bureau of Standards. Test readings obtained indicate good agreement

between the actual low temperature-emf characteristics of present standard grade Chromel-Alumel thermocouple wires and the values established by the NBS in 1934.

Valves

How to Select Control Valve Size. W. G. Holzbock. *Chem. Eng. 66,* 171 (1959) Apr. 20 (5 pp.)

Valve and process characteristics, as well as pressure drops in pipeline and valve, plus specific gravity, viscosity and volume of flow are all factors to be considered.

Select Special Control Valves to Handle Fluids with Unusual Properties Most Effectively. W. G. Holzbock. *Chem. Eng. 66,* 139 (1959) May 4, (6 pp.)

Special valves may control flow of fluids having unusual properties, such as valves for controlling small flows; toxic corrosive and valuable fluids; liquids containing abrasive materials; and slurries. Other valve designs provide control for low pressure drop through valve at high fluid velocities; for mixing or diverting flow; and for large flows at low liquid pressures. Also, certain valve operators can provide additional power at the valve stem to overcome unbalanced thrust forces on the valve plug. Valve specifications and maintenance of special and standard valves are further requirements to assure that correct valve action and adequate flow control will be provided.

What to Consider When Selecting Globe and Gate Valves. C. A. Dopp. *Heating, Piping & Air Conditioning 31,* 141 (1959) Apr. (20 pp.)

Globes and gates are the two most commonly used types of valves in power and process piping systems. Each is suitable for a particular service — globe valves for throttling or flow control, gate valves for stop or shut-off service. Each is made in a number of designs to satisfy the requirements of the many different services encountered in power and process piping systems. Selection of the proper seating design, operating means, and bonnet connection is essential for satisfactory valve performance. Failing to consider these components in design and selection may result in expensive valve maintenance or replacement. Data on the selection of gate and globe valves and their important components for successful application are subject of comprehensive report.

Heat Exchangers

Method of and Device for Recovering Energy when Cooling Compressed Gases in Heat Exchangers. F. A. Horn (assigned to Ruhrgas AG.) U.S. 2,875,589 (1959) Mar. 3.

Cooling of gases compressed in one or more stages is carried out in heat exchangers which are arranged subsequent to the compression stages in such a way that a vapor is employed as the heat transfer fluid in the heat exchangers which vapor has a low critical temperature lower than the temperature of the compressed gas to be cooled, but higher than atmospheric pressure. Method makes it possible to carry out the circulation of the heat transfer fluid at high pressure and due to the small vapor volume of the heat transfer fluid inherent thereto it is possible to carry out the method with relatively small devices and expanding machines while the method has a high degree of efficiency.

11. MATERIALS OF CONSTRUCTION, AND CORROSION

Cathodic Protection

How to Design Impressed Current Systems. J. C. Bell. **Part 1.** *Pipe Line Ind. 10,* 40 (1959) Mar. (8 pp.); **Part 2. Attenuation Factors.** *Ibid.,* (1959) Apr. (4 pp.)

Part 1 discusses attenuation factors, influence of pipe size and coating condition, while Part 2 discusses attenuation factors in more detail. Attenuation curves tell where protection current will be going on the line and show effects of coating quality and terminal conditions on current distribution. Ideal conditions—a uniform line of infinite length and a remote source of current—seldom, if ever, exist. But practical systems can be designed using these equations.

Use of Magnesium for Cathodic Protection of Pipelines in High Resistivity Soil. A. W. Peabody. (Chicago: NACE Fifteenth Annual Conference.) Paper No. 79 (1959) Mar. (15 pp.)

Experience with the system installed by South Georgia Natural Gas Company has indicated that it is entirely practical to cathodically protect a well-coated pipeline system in high resistivity soil with magnesium anodes. Performance is excellent and is attained with a minimum of operating and maintenance effort. Where magnesium anodes must be installed in high resistivity soil, long, slender anodes appear to be a satisfactory current source and, on this system, resulted in satisfactory distribution of protective potentials with anode beds protecting an average of approximately 45 miles of pipe per bed.

Coatings

Characteristics and Cost Factors: Glass Fiber Reinforcement for Coatings. *Corrosion 15,* 102 (1959) Apr. (2 pp.)

Use of glass fibers as reinforcement in coal tar enamels for corrosion control of underground pipe is presented. Resistance of glass fiber to impact, atmospheric conditions and chemical attack is given with data presented in tables to show the properties and cost factors of basic fiber types, mats and cloths. Possible future applications of other fiber types also are discussed briefly.

High Precision Nondestructive Thickness Measurements of Organic Coatings. E. P. Brightwell. *ASTM Bull. No. 237,* 67 (1959) Apr. (3 pp.)

Averages of replicate thickness measurements using the infrared technique are compared with values obtained by direct measurement using an optical slit microscope. Direct method is less sensitive than infrared technique and it is destructive. Accuracy of the infrared technique is greatly reduced by the use of a rough substrate such as bonderized steel.

Tape Wrapping Pipe Fittings. *Gas 35,* 72 (1959) Apr. (3 pp.)

Field experience in applying pressure-sensitive tapes has shown that problems exist in tape wrinkling and buckling, causing undesirable voids. Using the experience of those applying the tape in the field, Minnesota Mining & Manufacturing Co. has developed new methods of wrapping which incorporate a specially designed pipe putty to provide a smooth wrapping surface by eliminating voids in irregular fittings. By causing pipe putty to round out sharp corners on couplings and other fittings, wrinkles and folds can be eliminated.

Corrosion

Corrosion: Holes in the Oil Industry's Pockets. H. A. Stiff, Jr. *Petrol. Eng. 31,* B-19 (1959) May (6 pp.)

First step in corrosion control is to recognize it and estimate its economic extent. In the production end of the oil business the probable economic extent of corrosion can be determined by studying the well records, field histories and test data, and serving equipment. At present, oil industry pays an annual cost of about $2 billion in the fight against corrosion. This is 36% of the total corrosion costs of all industry. Expenditures, in order of amounts, are for paints and coatings, metallic alloys, underground pipe maintenance and replacement, and repair and maintenance of operating equipment, including refineries and transportation facilities.

Corrosion Problems Associated with Sour Gas Condensate Production. D. R. Fincher. (Chicago: NACE Fifteenth Annual Conference.) Paper No. 27 (1959) Mar. (9 pp.)

Safety is one of the most important phases of an operation as described in paper. Adequate protection of equipment is of great importance. Experience and data gained in producing and processing sour gas condensate from the New Hope Field Smackover Lime formation indicate both obligations of safety and protection of personnel can be fulfilled by 1) design of equipment to remove water at all possible points; 2) use of standard equipment with special corrosion resistant materials at critical locations; 3) use of a constantly supervised corrosion inhibitor program, and 4) design of equipment with adequate strength, yet using ductile materials. Constant study and reevaluation of data, means and methods also are important factors in any such program.

Corrosion of Refinery Equipment by Aqueous Hydrogen Sulfide. NACE Tech. Comm. (Rep. 59-12). *Corrosion 15,* 189t (1959) Apr. (5 pp.)

H_2S corrosion problems at temperatures below 400°F in the presence of water are presented for a wide range of refinery equipment. Most commonly accepted solution to the problems of corrosion and fouling are the use of resistant alloys and/or neutralization plus film-forming corrosion inhibitors. Experience at several units employing steel condenser tubes exposed to waters contaminated with H_2S and other acids are discussed. Theoretical study of corrosion of steel in H_2S solutions reveals that for prevention of high velocity, low *p*H exposures should be an effective control measure. Analysis of several failures of steel-tubed exchangers are discussed in the light of additional improvements that may be possible in design and selection of materials. Preliminary tests indicate that zinc or aluminum coated steel tubes may be useful in this environment.

An Industrial Experience of Severe Metal Wastage Resulting from Contact with Synthesis Gas from a Generator in which Methane Was Burned with Oxygen. F. Eberle and R. D. Wylie. (Chicago: NACE Fifteenth Annual Conference.) Paper No. 15 (1959) Mar. (11 pp.)

Observations during examination of the affected metal parts and test specimens led to the conclusion that the following factors may have been involved in the wastage phenomenon: 1) Cycling temperature-oxidation; 2) cycling carburization and oxidation; 3) cycling oxidation and reduction and 4) partial conversion of the outermost surface to solid carbide by continuous carburization and flaking of the brittle layer.

Metal Deterioration in Atmospheres Containing Carbon-Monoxide and Hydrogen at Elevated Temperatures. W. B. Hoyt and R. H. Caughey. (Chi-

cago: NACE Fifteenth Annual Conference.) Paper No. 14 (1959) Mar. (11 pp.)

Description of an unusual type of deterioration which has been experienced on stainless steel equipment exposed to atmospheres containing carbon-monoxide and hydrogen at temperatures in the approximate range of 800-1300° F. This deterioration has taken the form of pitting and general metal loss without the formation of adherent scales but accompanied by carburization of the attacked metal surface. Tentative theory to explain this form of deterioration has been offered by the authors for consideration.

Oil Refinery Applications of Thick-Film Synthetic Coatings. R. W. Maier, W. B. Cook and R. B. MacQueen. *Corrosion 15,* 171t (1959) Apr. (8 pp.)

Three recent developments in synthetic protective coatings have made relatively thick film applications per coat without resulting in sags, runs or skin-dry wrinkling. These developments are hot spray applications, catalyst-cured coatings and high-film-build alkyd paints. Article discusses: Hot spray vinyl, catalyst-cured epoxy, catalyst-cured epoxy-modified phenolic and high-film-build alkyd coatings and also the advantages derived from their application to oil refinery equipment. Coating problems involved in protecting oil refinery equipment are noted, and field experiences with thick-film applications on various equipment surfaces exposed to a wide range of contact media and conditions are described. With the exception of high-film-build alkyd paint, field data are given in tables and are described in detail in the text.

Graphite

Graphite as a Material of Construction for Heat Exchangers. A. Hilliard. *Chem. Process Eng. 40,* 127 (1959) Apr. (3 pp.)

Mechanical and physical properties of graphite differ in many respects from those of the commonly used metals, and different design considerations are therefore applicable. To employ graphite to best advantage, it is necessary to base the design on the properties of the material alone, ignoring previous practice with other materials. Particular attention must be given to the fact that graphite is highly anisotropic and its compressive strength is much better than its tensile or flexural strength. Whereas the compressive strength of a good constructional graphite would be of the order of 15,000 psi, its tensile strength is only a fraction of that figure. Furthermore, graphite is neither malleable nor ductile. To effectively exploit the good compressive strength of graphite, it is necessary to use it in the form of strong blocks.

Inhibitors

Inhibitor Evaluation from Cathodic Polarization Measurements. R. A. Legault and N. Hackerman. (Chicago: NACE Fifteenth Annual Conference.) Paper No. 25 (1959) Mar. (15 pp.)

Method of Kaesche and Hackeman for determining the efficiency of pure organic amines as corrosion inhibitors of iron has been extended to include some more complex carboxylic acid salts of technical grade polyamines in the forms in which they are used commercially for the mitigation of iron corrosion. It has been found that the carboxylic acid portion of the amine salts used contributes but little to the actual process of inhibition, although various advantages may be derived from the use of the salt in preference to the free amine, such as increased solubility in the corrosive medium. It has been demonstrated that the efficiency of the complex materials used commercially for corrosion inhibition of iron and steel can be determined in the presence of carbon dioxide, in the presence of a second, non-conducting phase, and in $_{p}$H ranges approaching neutrality. Method described in paper provides a rapid and relatively accurate means of evaluating the efficiency of corrosion inhibitors in systems which are in *p*H ranges of commercial interest.

12. ANALYTICAL METHODS AND TESTS

Carbon Monoxide

Rapid Method for Determination of Small Amounts of Carbon Monoxide in Gas Mixtures. I. Lysyj, J. E. Zarembo and A. Hanley. *Anal. Chem. 31,* 902 (1959) May (3 pp.)

Gravimetric method is developed for determining carbon monoxide in gas mixtures. Carbon monoxide is converted to carbon dioxide and absorbed in an Ascarite tube. Method is sensitive to 0.1-0.5% carbon monoxide in 500 ml of gas. For smaller concentrations larger sample volumes are required.

Chromatography

Alumina as a Column Packing in Gas Chromatography. C. G. Scott. *J. Inst. Petrol. 45,* 188 (1959) Apr. (5 pp.)

Article describes a study of the adsorptive properties of alumina in terms of retention volume data for ethane, ethylene and propane from which it has been possible to deduce the necessary column packing characteristics to obtain a complete separation of hydrogen and 14 hydrocarbons, ranging from methane to *n* pentane on one comparatively short

column operating at room temperature. Relationship of the gas chromatographic data to the surface properties of the alumina also is discussed.

Gas Chromatographic Determination of Dissolved Oxygen in Lubricating Oil. P. G. Elsey. *Anal. Chem. 31,* 869 (1959) May (2 pp.)

Chromatographic technique is developed for determining oxygen in lubricating oil. Sample is passed over a molecular sieve column and oxygen is separated and determined. Method is applicable for the determination of other gases.

Gas Chromatographic Determination of Fuel Dilution in Lubricating Oils. R. S. Porter and J. F. Johnson. *Anal. Chem. 31,* 866 (1959) May (4 pp.)

Gas chromatographic method has been developed for measuring fuel dilution in crankcase oil. Apparatus consists of a preheater block which flashes the diluent from the oil into a helium stream, a precolumn which condenses oil entrained in the helium flow, and a gas chromatographic column which resolves and measures the amounts of diluent. Results are based on the use of an internal standard placed in known concentration in each determination. Extensive calibration tests indicate that the chromatographic method is the most sensitive and accurate analysis yet available for measuring fuel dilution. Supplementary advantages over distillation analyses are that small samples are used, the test is simple, the volatility range of the diluent is indicated and the chromatographic chart provides a permanent record.

A Gas Chromatography Study of the Adsorptive Properties of a Series of Activated Charcoals. H. W. Habgood and J. F. Hanlan. *Can. J. Chem. 37,* 843 (1959) May (13 pp.)

From measurements of the gas chromatographic reaction volumes, the initial slopes of the adsorption isotherms of nitrogen and the simpler hydrocarbons on a series of steam-activated coconut charcoals were determined. Initial heats of adsorption were obtained in the usual way from the temperature dependence. It was found for all gases that both the initial slope of the isotherm and the initial heat of adsorption decreased with increasing degree of activation of the charcoal (i.e., with increasing surface area per g). This suggests that the higher affinity for the very small pores in less activated material more than counterbalances the lower total surface. Measurements at several different carrier gas flow rates of the relative band width for the charcoals of least and of greatest activation demonstrated, as might be expected, a greater resistance to mass transfer for the former. However, the apparent diffusion coefficients calculated on the assumption that all transport is by gas phase in the pores were nearly the same for each charcoal and showed relatively little variation among the different gases.

New Methods for Study of Hydrocarbons with Consideration of Gas Chromatography and Infrared Spectroscopy. F. Eckhardt and H. O. Heinze. *Erdöl u. Kohle 12,* 83 (1959) Feb. (5 pp. German text.)

Applications of the Perkin-Elmer & Co. GmbH gas fractometer in analysis of gas hydrocarbons are discussed, as well as the use of infrared techniques for detecting impurities in gas plant byproducts.

Gas Analysis

Precision Apparatus for the Preparation of Calibrated Gaseous Mixtures. D. Sordelli. *Rivista dei Combustibili 13,* 122 (1959) Feb. (14 pp. Italian text.)

To study and develop techniques and methods for analysis and research on gases and vapors, it is indispensable to have available calibrated blends of the various known or probable components under examination. To meet this requirement an apparatus has been designed, built and lined-up which is easy to use and, since it can provide high precision calibrated blends of a large number of gases and vapors, for any range of composition up to fractions of ppm, it can be adapted to a very wide field of application. By way of explanation some typical applications are described for use in analysis, in gas research, in air pollution studies and in industrial hygiene and toxicology.

Gas Sampling

Correct Procedures for Field Sampling Gas. N. E. Watson. *World Oil 148,* 188 (1959) Apr. (2 pp.)

Because no analysis has greater accuracy than that of the sample from which it is made, results of analytical tests on natural gas depend on the care with which the sample is obtained and transported. Because conditions vary widely, special precautions must be observed when obtaining samples since some natural gases contain condensable constituents; others, appreciable quantities of constituents which may react with ordinary materials such as iron, steel, copper, brass and rubber. These require particular sampling techniques.

Hydrocarbons

Hydrocarbon Compound-Type Analysis of Automobile Exhaust Gases by Mass Spectrometry. D. M. Coulson. *Anal. Chem. 31,* 906 (1959) May (5 pp.)

Method of hydrocarbon-type analysis of gaseous mixtures such as automobile exhaust gases is based on mass spectrometry. Mercuric perchlorate and per-

chloric acid on granular firebrick were used to remove olefins and acetylenes in the gas phase. Olefinic components were removed by taking an aliquot of the gaseous sample into the mass spectrometer through an absorption column packed with mercuric perchlorate-treated firebrick. By comparing this spectrum with that of an untreated sample, a clean separation of the spectra of paraffinic and olefinic compounds could be made. Results are interpreted in terms of the hydrocarbon types—paraffins, cycloparaffins, mono-olefins, acetylenes, and cyclo-olefins, and aromatics.

Mercaptans

Titrimetric Determination of Alkyl Mercaptan-Dialkyl Sulfide and Alkyl Mercaptan-Alkyl Disulfide Mixtures. B. Jaselskis. *Anal. Chem. 31,* 928 (1959) May (4 pp.)

Mixtures of *n*-alkyl mercaptans and dialkyl sulfides can be determined titrimetrically using two aliquots. First aliquot is titrated for mercaptan with iodine, and the second, after treatment with basic acrylonitrile, is acidified and titrated with bromatebromide solution. Amount of dialkyl sulfide is found by the difference. Results agree to better than 1%. Mixtures of *n*-alkyl mercaptans and alkyl disulfides are determined iodimetrically. Mercaptan alone is titrated first, and then the total mercaptan is titrated after the reduction of alkyl disulfide with zinc in an acetic-hydrochloric acid-alcohol mixture. Alkyl disulfides with higher molecular weights than propyl disulfide are recovered quantitatively.

Metals

Identification of Corrosion Products on Copper and Copper Alloys. NACE Tech. Comm. (Rep. 59-13). *Corrosion 15,* 199t (1959) Apr. (3 pp.)

Description is given of micro-chemical analytical methods that can be used to identify corrosion products on copper and copper alloys. Both soluble and insoluble constituents can be identified by these methods. Constituents discussed in detail include oxides, chlorides, sulfates, sulfides, carbonates, silica calcium, magnesium, sodium, ammonia and metal constituents of the material being examined. Method for spectrographic examination of corrosion products is considered briefly.

Nickel

Spectrophotometric Determination of Traces of Nickel with 4-Isopropyl-1, 2-Cyclohexanedionedioxime. B. L. McDowell, A. S. Meyer, Jr., R. E. Feathers, Jr. and J. C. White. *Anal. Chem. 31,* 931 (1959) May (4 pp.)

Use of xylene rather than chloroform to extract the nickel (11)-4-isopropyl-1, 2-cyclohexanedionedioxime chelate results in increased sensitivity in the spectrophotometric determination of nickel. Extraction coefficient in xylene is more than five times as great as that in chloroform, and the low solubility of xylene in aqueous solution permits the use of much larger phase ratios (aqueous to organic). System conforms to Beer's law for concentrations of nickel 1 to 12γ of nickel per ml of xylene. Precision of the method is 2%. Iron, cobalt and copper interfere seriously, however, their interference can be minimized so that weight ratios of metal to nickel of 20, 2 and 8, respectively, can be tolerated. Concentrations of nickel from 0.005 to 100 ppm were determined in water, alkali metals and several analytical reagents. Recoveries in excess of 95% were obtained when known amounts of nickel were extracted from aqueous solutions of relatively high ionic strength at aqueous-to-organic volume ratios as high as 300 to 1.

Radioactivity Applications

Nuclear Radiation Finds New Horizons in Process Instrumentation. E. J. Fresh. *Petrol. Eng. 31,* C-10 (1959) Apr. (5 pp.)

Application of radiation gaging techniques to measurement problems in refineries is quite broad. Article attempts to aid reader in evaluating the applicability of radiation measurements to specific process problems by discussing principles on which these measurements are based and citing a few examples. Use of radiation instrumentation as a powerful research tool for special measurements should be apparent. However, the major benefit of radiation measurement is derived from use in routine process control. Fortunately, reliable instruments are now available as standard, well-engineered units, making their routine usage feasible and economical.

Spectography

Application of Emission Spectrography and Ultra-Violet to the Study of Separation of Nickel in Catalysts. A. Asselin. *J. Ind. du Gaz 83,* 119 (1959) Mar. (3 pp. French text.)

Principles, problems, techniques and spectra are briefly described.

Spectrophotometry

Spectra of Free Radicals. G. Herzberg. *Proc. Chem. Soc.,* 116 (1959) Apr. (12 pp.)

Author discusses certain chemical problems from viewpoint of spectroscopist. Free radicals discussed include C_3, SiC_2, NH_2 HCO, HNO, NCO, NCS, CH_3, H_2, and C_2H. Work is important to chemist interested in establishing presence of free radicals in various chemical reactions and to the physicist interested in structure of simple molecules.

13. BASIC SCIENCE

Acetylene

The Electronic States of *Cis*- and *Trans*-Acetylene. H. Howard and G. W. King. *Can. J. Chem 37,* 700 (1959) Apr. (8 pp.)

Electronic energy levels of *cis* and *trans*-bent planar centrosymmetric acetylene molecules, with <CCH = 120° and r_{cc} = 1.383A, have been calculated by the LCAO/ASMO/CI procedure. Lowest energy state that can spectroscopically combine with the linear ground state is found to be of symmery class A_u belonging to the *trans*-bent molecule and to lie at 4.58 ev above the ground state. This compares favorably with the experimentally observed electronic transition of lowest energy which is of the type (^1A_u — $^1E_g^+$) and at 5.24 ev. Lowest-energy allowed transition to a *cis*-bent state of these dimensions is at 9.39 ev and hence this may not form part of the unanalyzed system of bands in the 2000-1500 A region, as has been suggested. However, a transition to a *trans*-bent state of type (^1B_u — $^1E_g^+$) is predicted to fall in this region. The energies of other electronic states are discussed in relation to the observed absorption systems of acetylene.

Adsorption

Adsorption and Catalysis. P. H. Emmett. *J. Phys. Chem. 63,* 449 (1959) Apr. (8 pp.)

Article points out many ways in which adsorption has become related to catalytic action and to the study of catalysts, and also reviews general direction along which progress is being made toward establishing a firm scientific explanation for the behavior of catalysts. Article mentions magnetic, conductivity and infrared measurements, but in addition there are nuclear magnetic resonance, contact potential, X-ray and electron miscroscope measurements which were not discussed because of space limitations. It is predicted that the next ten years or so will witness more progress in putting catalysts on a truly scientific basis than has been made in all work up to the present time.

Heats of Adsorption of Hydrogen on a Singly Promoted Iron Catalyst. R. A. Beebe and E. R. Camplin. *J. Phys. Chem. 63,* 480 (1959) Apr. (4 pp.)

Early work has indicated the presence of two types of chemisorption of hydrogen on iron catalysts. These types, designated as A and B, proceed fairly rapidly at temperatures around 0 and 200°, respectively. More recently Kummer and Emmett have shown that "singly promoted iron catalysts, unlike doubly promoted catalysts, rapidly catalyze the hydrogen-deuterium exchange reaction at —195°." On the basis of this observation and of the adsorption data for the hydrogen-iron system, these authors postulate a third kind of chemisorption, called Type C, occurring in the low temperature region. Authors undertook calorimetric measurement of the heats of adsorption of hydrogen on the singly promoted iron catalyst to sort out the three types. At 0° and —195° the heat values range from 16.5-8.0 (at 0°) and from 5.4-1.6 kcal/mole (at —195°) for successive increments of hydrogen. Rather crude measurements at —200° indicate heats ranging from 27-15 kcal/mole. Calorimetric results at —195° confirm the prediction of Emmett and Kummer that the heat of Type C adsorption would be "considerably greater than that of the heat of physical adsorption but at the same time considerably smaller than the heat of either Type A or B hydrogen adsorption."

Butane

The Solubility of *i*-Butane in Water. C. D. Reed and J. J. McKetta. *Petrol. Refiner 38,* 159 (1959) Apr. (2 pp.)

Article covers the two-phase equilibrium between the water-rich liquid phase and the hydrocarbon-rich gas phase. In this study, the pressure of the system was held below that necessary for the appearance of a third phase, a hydrocarbon-rich liquid phase. Equilibrating equipment and analytical techniques were essentially the same as those described earlier. (See *Gas Abstracts 14,* 352.) Static method is used whereby the water and the *i*-butane are placed into an equilibrium cell, the cell is rocked for several hours, then the water-rich liquid phase is sampled directly into the analytical train.

Carbon

The Oxidation of Carbon by Nitric Oxide. R. N. Smith, J. Swinehart and D. Lesnini. *J. Phys. Chem. 63,* 544 (1959) Apr. (4 pp.)

Below 200° NO reacts with an ashless sugar charcoal to give N_2 and carbon-oxygen surface complexes, the reaction ceasing when the surface is saturated with complexes. In the temperature range 450-600° the reaction is first order, proceeds continuously, and yields N_2, CO_2, CO and carbon-oxygen surface complexes. Activation energy varies from 15.0-18.3 kcal/mole, depending on the nature of the surface. It is postulated that a NO molecule reacts with another adsorbed at the site of a surface oxygen complex to give N_2 and CO_2, and an oxygen complex on an adjacent carbon atom. New oxygen complex usually serves as a site for further adsorption of NO and continuing reaction, but its location may be unstable and CO may be the product instead. H_2-treatment of the surface decreases the rate, and O_2-treatment increases the rate of reaction.

Equation of State

A Simple Equation of State for Gas Mixtures and Its Application to the Ternary Mixtures H_2-N_2-CH_4. A. DiCio. *Rivista dei Combustibili 13,* 208 (1959) Mar. (9 pp. Italian text.)

With reference to the method developed by Paoluzi for correlating the variables P,V,T in gas mixtures when for each component an equation of state is observed of the type $p=f(T,V-b)-\frac{a}{V^2}$, it is proposed, in the case of binary and ternary mixtures formed of H_2, N_2, CO, CH_4, to ascribe the value 1 to the general constant of interaction (Units: liters, atm, °K). Employing the Paoluzi equation for the mixture H_2, N_2, CH_4, in the temperature range from −30 to 250°C and pressures up to 400 atm, the discrepancy between computed and measured pressure is seldom above 1%, with a mean of 0.91%; employing the van der Waals equation, in the same temperature range and with pressures up to 300 atm, the discrepancy between computed and measured pressure is seldom above 3% with a mean of 2.39%.

Fluid Flow

Conversion of Equations of a Turbulent Boundary Layer in Gas to Linear Ordinary Differential Equations and Their Solution in Final Form. L. E. Kalikhman. *Dokladi Akad. Nauk SSSR 106,* 401 (1956) (4 pp. Russian text); *Ref. Zh. Mekh.* Rev. 7982 (1957) No. 7. (From *Appl. Mech. Rev. 12,* 266 (1959) Apr.)

Conversion is shown of the integral correlations of impulses and energy to two linear ordinary differential equations, based on the introduction of new functions and use of an assumption regarding the constancy of some values subject to only small variations. Integrals of these equations are essentially functions, one of which is proportioned to the relation of the amount of impulse loss to the surface friction stress, while the other,—the relation of the amount of energy loss to the square of the heat emission. Friction stress, heat emission coefficient and the other characteristics of the boundary layer can be determined after the establishment of the formulas for resistance and heat emission. It was found that analogous results are obtained in the case of an axially symmetrical flow of gas.

A. A. Yarkho

Courtesy *Referativnyi Zhurnal,* USSR

Translation, courtesy Ministry of Supply, England

Heat Transfer

Air Wins, Even with Water Plentiful. J. W. Thomas. *Petrol. Refiner 38,* 103 (1959) Apr. (3 pp.)

Article presents 1) economic comparison of air cooling vs water cooling for one large condenser at Sohio's Lima refinery and 2) an economic comparison of air cooling vs water cooling for Sohio's new 60,000-barrel refinery at Toledo, Ohio.

The Effect of Surface Temperature Variability on Heat Exchange in Laminar Flow in a Boundary Layer. G. S. Ambrok. *Soviet Phys.-Tech. Phys. 2,* 738 (1957) Apr. (11 pp. Russian text); translation of *Zh. Tekh. Fiz. Akad, Nauk SSSR 27,* 812 (10 pp.) by Amer. Inst. Phys. (From *Appl. Mech. Rev. 12,* 265 (Apr.) 1959.)

Author develops a relationship giving the coefficient for forced convection heat transfer from a nonisothermal flat surface. This relationship is in the usual form of $Nu=\psi\sqrt{R_e}$, where ψ is a complex function of the Prandtl modulus, and the velocity and temperature variation. Solution is illustrated with application to the case of x^m variation of velocity and x^n variation of temperature head, i.e., difference between surface temperature and undisturbed stream temperature. Cases of arbitrary variations require graphical or numerical solutions.

T. J. Connolly, USA

Heat Transfer to Liquids in Intermittent Flow. G. B. Darling. *Petrol. 22,* 177 (1959) May (2 pp.)

Work reported was conducted to determine if heat transfer to liquids could be usefully increased by the application of intermittent flow. Water and 50% glycerol solution in intermittent flow in a 0.379-in. diam heated tube gave poorer heat transfer than in steady flow when the flow was controlled from downstream of the heater. When the flow was controlled from upstream of the heater, bubbles appeared in the liquid and heat transfer was improved by up to 70% over the steady flow values. Bubbles were caused by cavitation on or near the heating surface during the deceleration of the moving liquid.

Heat Transfer Nomographs. J. Alvarez and C. Duhne. **Part 7. Heat Transfer Coefficients for Liquids and Gases Inside Tubes.** *Petrol. Refiner 38,* 158 (1959) Apr. (2 pp.); **Part 8. Heat Transfer Coefficient for Liquids and Gases Outside Tubes.** *Ibid.,* May (1959) 193 (2 pp.)

Part 7 presents two nomographs for determining film coefficients. One set can be used for finding the heat transfer coefficients for gases inside tubes while the other is for liquids. Method is time saving because of the resolution of the fractional power mass velocity coefficients into nomograph form. Similar method is applied in Part 8, where tedious calculation is resolved into an extremely useful nomograph.

Heat Transfer Rates between Heated Tubes and a Boiling Refrigerant. C. F. Staley and M. Baker. *ASHRAE J. 1,* 83 (1959) Apr. (7 pp.)

Object of research reported was to obtain experimental data for Refrigerant-22 and to correlate the data in terms of the physical properties of the refrigerant and fundamental parameters of the evaporator systems. At the present time there is no exact mathematical method for the determination of the inside conductance for boiling refrigerants flowing within a horizontal tube. This problem is both difficult and complex due to the lack of knowledge of the mechanism of boiling heat transfer. Studies in this important field generally fall into two broad categories; one is experimental determinations of coefficients for use as practical design data, and the second is the formulation of a general correlation based on fundamental parameters.

How to Design Tank Heating Coils. D. Stuhlbarg. *Petrol. Refiner 38,* 143 (1959) Apr. (8 pp.)

Design of tank heating coils has remained more or less an "art." Article presents formulas backed with experimental data for calculating heat losses, coil area and a discussion of factors which affect coil layout and location. Tank coil design falls naturally into two parts: Thermal and physical. The former, in turn, subdivides into determining the proper design basis, calculating the heat load on the coil and, finally, computing the coil area. Physical design includes selecting size, computing length, deciding on type of coil and location in the tank and then making the detailed layout.

How to Estimate Cooling Tower Costs. N. H. Prater and D. W. Antonacci. *Petrol. Refiner 38,* 119 (1959) Apr. (6 pp.)

Cooling towers are the largest type of industrial heat transfer equipment in use today and constitute one of the most difficult items of plant equipment to specify and evaluate. Purpose of article is to describe the basic types of induced draft cooling towers, factors to be considered in preparation of design specifications, economic considerations in selecting the tower, and to present a method for accurately estimating the cost of cooling tower installations. Data are given on cooling tower prices and installation costs in relation to capacity and design operating conditions for towers of capacities up to 75,000 gal/min of water.

For Shell-Side Fluids Heat Transfer and Pressure Drop . . . in Transverse Finned Shell-and-Tube Exchangers. N. H. Chen. *Chem. Eng. 66,* 141 (1959) Apr. 6 (4 pp.)

Transverse fins in shell-and-tube heat exchangers find wide acceptance for heating and cooling of process fluids. Charts presented enable rapid calculations of shellside heat transfer coefficients and pressure drops in transverse finned shell-and-tube heat exchangers. Calculations for traverse fins follow general methods established for bare tube exchangers except for a modification in tube diameter. An equivalent diameter D_e is used for the finned-tubes instead of nominal diameter D_o which was used for the bare tubes.

Hydrocarbons

Applied Hydrocarbon Thermodynamics. Part 10A: Charts for Making Compressor Calculations. W. C. Edmister. *Petrol. Refiner 38,* 161 (1959) Apr. (7 pp.)

Compressor design includes calculations of 1) temperature rise of the gas, 2) work of compression and 3) compressor size. Exponents defining temperature and volume changes with pressure are useful in making these calculations for both centrifugal and reciprocating compressors. Charts presented in this article are of use in making such calculations, especially for reciprocating compressors. Generalized relationships were developed in previous installments (see *Gas Abstracts 14,* 243) for reversible adiabatic (isentropic) and reversible polytropic paths. From these correlations, charts giving exponents for eight typical gases have been prepared and are given. Two other charts, showing the isentropic exponent as a function of gas gravity, olefin content, temperature, and pressure, also are included. In addition an irreversibility correction to the temperature change exponent has been developed.

Mass Transfer

Use New Graphical Method: Find Mass Transfer Units. O. T. Hanna. *Chem. Eng. 66,* 127 (1959) Apr. 6 (4 pp.)

For mass transfer calculations, the height of a transfer unit concept has been useful. With it, the problem of determining the tower packing height is divided into two parts: finding the height of a transfer unit H, and finding the number of transfer units N. Of course, the H and N used to calculate the packed height must be based on the same driving force.

Mathematical Methods

Statistics in the Strategy of Chemical Experimentation. S. L. Andersen. *Chem. Eng. Progress 55,* 61 (1959) Apr. (7 pp.)

Aim of most chemical investigations is to predict the behavior of a process or the properties of a product. Effective experiment is one which results in the broadest possible reliable predictions from a specified amount of experimental effort. To obtain

effective prediction from chemical experimentation, full use should be made of modern statistical methods to complement, not replace, engineering and chemical principles.

Thermoelectricity

On the Theory of the Peltier Heat Pump. E. S. Rittner. *J. Appl. Phys. 30,* 702 (1959) May (6 pp.)

Figure of merit for a single-stage Peltier heat pump is optimized in the region of partial Fermi degeneracy. A more rigorous treatment is presented of the propeties of a cascade operating at maximum coefficient of performance. Finally, the heat leak in the absence of current flow is called to attention as a serious problem in devices with excess capacity.

Viscosity

Estimate Gas or Liquid Viscosity Data. C. J. Huang and A. I. Johnson. *Petrol. Refiner 38,* 217 (1959) May (10 pp.)

Viscosity is a problem which appears in all fluid flow, and heat and mass transfer correlation. It is usually a property which must be known as accurately as possible. In general, correlating methods discussed in article are empirical. Authors also point out the definitions on which viscosity is based, i.e., absolute viscosity, kinematic viscosity, fluidity, critical viscosity, reduced viscosity, relative viscosity and the reochor.

Nomographs present methods of determining viscosity of a vapor or liquid when this property is known at two different temperatures; for vapor viscosities at high and low temperatures and for liquid viscosity measured in a laboratory.

Ultrasonics

Ultrasonic Energy . . . in Theory and Application. E. B. Wright and R. C. Cheek. *Westinghouse Engineer 19,* 71 (1959) May (5 pp.)

When the sound intensity is increased well above that needed for detection systems, a whole new area of applications arises. For instance, ultrasonic energy can be used to tin without flux, weld, drill, clean, speed up chemical reactions, and perform a host of other jobs. While these potential applications have been discovered since World War II, equipment to perform these jobs is in various stages of development. Most important high-power application of ultrasonics in industry is that of cleaning or degreasing. Fascinating aspect of ultrasonic energy is that it can be applied in various ways, with completely different results. Many new ultrasonic devices are now in the experimental stage and new applications constantly arise, which is a strong indication that ultrasonic energy will become an important and useful tool for industry.

Water

Seven Answers from One Chart . . . Physical Properties of Water. W. R. Gambill. *Chem. Eng. 66,* 139 (1959) Apr. 6 (2 pp.)

Article presents a chart which gives the physical properties of water pertinent to heat transfer design. Chart covers range from 0-340°C. Properties given are liquid density, in lb/CF; latent heat of vaporization, in Btu/lb; liquid heat capacity at constant pressure, Btu/(lb) (°F); surface tension, expressed in dynes/cm; liquid thermal conductivity, Btu/(hr)(ft)(°F); liquid viscosity, in centipoises, and liquid phase Prandtl number.

Services Available to GAS ABSTRACTS' Readers

Photocopies

Photocopies of all articles abstracted in *Gas Abstracts,* except those printed in Russian (see below), are available from the Institute at cost.*

Types of Photocopies

Depending on the "tightness" of the binding (which determines whether pages can be laid flat without breaking the binding), and the color of the paper and ink used in the original being copied, photocopies may take any of several forms:

1. Positive paper prints made by the reflex process.
2. Positive paper prints enlarged by xerography from microfilm negatives.
3. Negative photostats.
4. Positive photostats.

Choice of the method used must necessarily rest with the Institute. All photocopies are approximately the same size as the original material.

Cost of Service

The photocopy service charge is:

First 5 pages or fraction thereof of one article in one issue or book.....$1.50

Each subsequent 4 pages or fraction thereof of the above one article in the same issue or book..$1.00

Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

Microfilm

Microfilm copies of articles abstracted in *Gas Abstracts* are likewise available at cost.* The material is photographed on 35 mm unperforated negative film at 5¢ per page, with a minimum of 50 pages, $2.50, per order. Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

Russian Translations

The abstracts of Russian articles are obtained from services specializing in this field. English translations of the articles abstracted can be supplied by arrangement with the appropriate abstractor.

Bibliographies and Literature Searches

The library will prepare bibliographies and make literature searches on a cost basis plus a service charge. A comprehensive statement detailing the problem must be presented with the request.

Gas Abstracts on Cards

The abstracts in each monthly issue are also printed individually on 5 x 8-inch cards. Each card bears at its top the author and subject headings under which it may be filed. As many copies of each card are supplied as there are headings on that card, enabling filing of the abstract under all of its headings, eliminating cross-indexing.

The annual subscription to *Gas Abstracts on Cards,* a mailing of 500-1000 cards each month, is $120.00 to U. S. addresses, $150.00 foreign.

Since the printing order for cards is based on the current number of subscribers, a subscription for this service commences with the month in which the order is received. Back numbers of *Gas Abstracts on Cards* are not available.

Back Numbers of Gas Abstracts

In response to an increasing number of requests from utilities, colleges, and technical libraries which have only recently learned of the reference value of *Gas Abstracts,* the Institute has taken steps to make available single numbers, volumes, or complete files of this publication to date, starting with Vols. 1 (1945) and 2 (1946), some numbers of which are out of print.

The latter numbers are reproduced by a photoprinting process from copies in the Institute's libraries, and Vols. 1 and 2 can now be purchased at $35 per volume, unbound; single monthly numbers are offered at $3 each.

Vols. 3 to date are available at current subscription prices, $18 per volume to U. S. addresses, $22 foreign. Monthly numbers are $2 each.

---

*In requesting and accepting photocopies or microfilm copies, the applicant agrees to the following:

1. The applicant desires this duplication solely for use in lieu of loan or manual transcription. Responsibility for questions of copyright that might arise in this copying, and in the use of the copies, is assumed by the applicant.

2. The applicant understands that the Institute does not sell the photocopies, but merely performs the service of copying at the applicant's request; the fee paid is exclusively for such service and is established on the basis of no profit to the Institute.

3. The Institute reserves the right at its own discretion to decline to make photocopies requested, or to limit the number of copies, within the principle of fair use of copyrighted material.

Publications Abstracted for GAS ABSTRACTS

Air Conditioning, Heating and Ventilating
Air Engineering
Air Pollution Control Association, Journal of
American Chemical Society, Journal of
American Gas Association Monthly
American Gas Journal
American Institute of Chemical Engineers, Journal of
American Petroleum Institute Quarterly
American Society for Testing Materials Bulletin
Analytical Chemistry
Appliance Manufacturer
Applied Chemistry, Journal of
Applied Mechanics, Journal of
Applied Mechanics Review
Applied Physics, Journal of
Applied Spectroscopy
ARS Journal
ASHRAE J.
Australian Journal of Applied Science
Australian Journal of Chemistry
Basic Engineering, Journal of
Battelle Technical Review
Bituminous Coal Research
Brennstoff-Chemie (German)
British Coal Utilization Research Association Monthly Bulletin and Quarterly Gazette
Business Week
Butane-Propane News
California Oil World
Canadian Chemical Processing
Canadian Gas Journal
Canadian Journal of Chemical Engineering
Canadian Journal of Chemistry
Canadian Journal of Physics
Ceramics (British)
Chemical and Engineering Data, Journal of
Chemical Society, Proceedings (British)
Chemical and Engineering News
Chemical & Process Engineering
Chemical Education, Journal of
Chemical Engineering
Chemical Engineering Progress
Chemical Physics, Journal of
Chemical Processing
Chemical Reviews
Chemical Society, Journal of (British)
Chemical Society, Proceedings (British)
Chemical Week
Chemistry & Industry (British)
Coal-Heat
Coal Utilization
Coke and Gas (British)
College Placement, Journal of
Combustion
Combustion and Flame (British)
Compressed Air
Computers and Automation
Construction Methods and Equipment
Control Engineering
Corrosion
Corrosion Technology (British)
Cost Engineering
Design News
Drilling
Electronics
Engineering for Industry, Journal of
Engineering for Power, Journal of
Engineers' Digest (British)
Erdöl und Kohle
Faraday Society, Transactions of (British)
Fuel (British)
Fuel Efficiency (British)
Fueloil & Oil Heat
Gas
Gas Age
Gas & Oil Power (British)
Gas Council Research Communications (British)
Gas Heat and Comfort Cooling
Gas Industries
Gas Journal (British)
Gas Times (British)
Gas- und Wasserfach (German)
Gas World (British)
Gazovaya Promyshlennost (Russian)
Heating, Piping & Air Conditioning
Independent Petroleum Association of America Monthly
Industrial and Engineering Chemistry
Industrial Finishing (British)
Industrial Gas (American)
Industrial Gas (British)
Industrial Heating
Industrial Laboratories
Industrial Research
Industries du Gaz, Journal des (French)
Institute of Fuel, Journal of (British)
Institute of Gas Technology Research Bulletins
Institute of Petroleum, Journal of (British)
Institution of Gas Engineers Bulletins and Communications (British)
Instrumentation
Instruments and Control Systems
Izvestiya Akademii Nauk S. S. S. R. Otdelenie Khimicheskikh Nauk (Russian)
Khimiya i Tekhnologiya Topliva i Masel (Russian)
LP-Gas
Lubrication
Lubrication Engineer
Mathematical Tables and Other Aids to Computation
Mechanical Engineering
National and Space Administration Memorandum
National Fire Protection Association Quarterly
National Gas Bulletin of Australia
National Petroleum News
Nuclear Science and Engineering
Nucleonics
Oil and Gas Journal
Optical Society of America, Journal of
Organic Chemistry, Journal of
Petroleum (British)
Petroleum Engineering
Petroleum Refiner
Petroleum Technology Journal of
Petroleum Week
Physical Chemistry, Journal of
Physics and Chemistry of Solids (British)
Physics of Fluids (British)
Pipe Line Industry
Pipeline News
Power
Producers Monthly
Product Engineering
Progress (Pakistan)
Public Utilities Fortnightly
Research, Journal of
Research & Engineering; the Magazine of Datamation
Review of Scientific Instruments
Revue Generale du Gaz (Belgian)
Rivista dei Combustibili (Italian)
Science
Scientific Instruments, Journal of (British)
Svenska Gasverksföreningens Månadsblad (Swedish)
Technical News Bulletin
U.S. Bureau of Mines Bulletins, Information Circulars and Reports of Investigations
U.S. Patents
Uspekhi Khemii (Russian)
World Oil
World Petroleum